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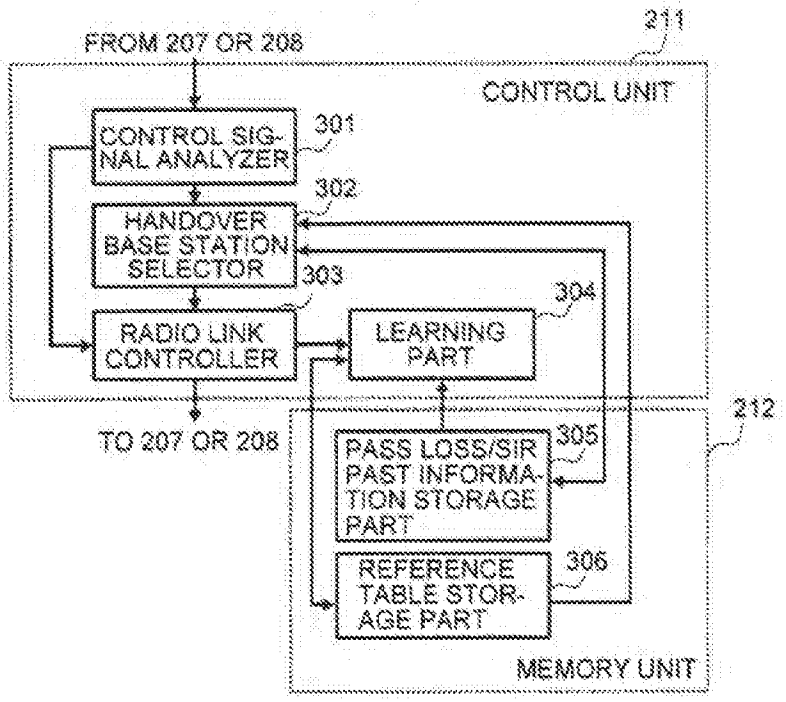
(54) A mobile communication system having a learning-type handover control method

(57) The present invention aims to reduce an unnecessary handover process incident to a sudden change in communication quality.

A collection circuit collects signal quality between a mobile station and respective base stations. A learning circuit learns data for judging handover, based on the signal quality. A determination circuit determines matching between the data for judging the handover and the signal quality collected by the collection circuit. A handover control circuit performs control on handover between the mobile station and a base station brought to a handover additional or deletion candidate of the mobile station, based on the result of determination by the determination circuit.

FIG.3A



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a mobile radio communication system (hereinafter called "CDMA mobile communication system") using code segmenting multiplex connection technology, and to a technique for performing more optimum handover.

[0002] In a mobile communication system, a mobile station selects or performs switching to a base station used as a communicating partner according to its movement, whereby the mobile station is able to communicate therewith continuously even if it moves. This base station switching operation is called "handover". A base station controller selects a base station low in pass loss of an electromagnetic wave transferred between a mobile station and each base station and large in signal to interference power ratio (hereinafter called "SIR") and connects the selected base station and the mobile station. In the present application, this operation is called "handover adding operation". On the other hand, the base station controller releases or sets free a connection to a base station related to handover, which is large in pass loss and low in SIR in order to reduce the occupation of an unnecessary radio line. In the present application, this operation is called "handover deleting operation". Thus, the mobile station is connected to a plurality of base stations which resembles in pass loss and SIR and sets free the connection to unnecessary base stations, whereby a high-quality communication state thereof is kept with the required minimum radio resources. Incidentally, the inventions disclosed in Japanese Patent Application Publication Laid-Open Nos. Hei 5-316023 and Hei 10-209948 are known as prior arts.

SUMMARY OF THE INVENTION

[0003] On the other hand, when a mobile station moves in building-dense regions such as cities, a pass loss and SIR suddenly change. Since only line quality of a perch channel at the present time makes an opportunity to perform handover in the related art, a handover adding operation and a handover deleting operation are frequently carried out when the pass loss and SIR continuously change suddenly.

[0004] The related art is based on the premise that a mobile station is connected to one base station alone, and never communicates with a plurality of base stations simultaneously. On the other hand, a CDMA mobile station is capable of being connected to a plurality of base stations simultaneously by taking advantage of a CDMA system (it is not uncommon that the mobile station is connected to three base stations simultaneously). Therefore, it is difficult to suitably select a base station brought to a handover additional candidate or a base station brought to a handover deletion candidate. Thus, an unsuitable candidate might be selected. Since the handover is processed using a connected time or the mean value of maximum transmitter power levels in the related art, a base station which is free of existence in a moving direction, i.e., is not to be originally connected, is brought to a handover candidate depending on a call time or the like of a mobile station having carried out the handover in the past. Also, even in the case of a sector type base station in which one cell is divided into a plurality of areas, handover processing much than required might be performed. There is, for example, a case in which a mobile station approaches right at the sector base station and radio waves from a plurality of sectors can be received with substantially the same pass loss and SIR.

[0005] If the base station not to be connected or originally set free is taken as the candidate for handover processing in this way, then the repetition of unnecessary handover adding/deleting operations might occur continuously. Thus, if the unnecessary handover adding operation and handover deleting operation are repeated, various resources such as CPU, a radio resource, etc. are consumed than required by the mobile station, base stations and base station controller. This consumption would bring about a delay with respect to the operation to be originally performed by the corresponding mobile station or another mobile station, thus leading to degredation in communication state. Further, the unsuitable execution of handover results in cutting-off of a calling.

[0006] Therefore, an object of the invention of the present application is to effectively take advantage of resources by reducing unnecessary handover. Another object of the invention of the present application is to reduce unnecessary handover so as to improve a processing delay of a system and provide more stable and high-quality communications.

[0007] According to the invention of the present application, as a method of solving the above-described problem, time-sequential data about pass losses and SIR (or transmitter power level and communication quality at base stations) of channels intended for the measurement of received levels, which are transmitted from connected base stations and non-connected base stations to a mobile station, and learning data are compared, and a handover additional base station or a handover deletion base station is selected from the degree of similarity thereof. As the learning data, ones (hereinafter called "reference tables") obtained by updating the above-described time-sequential data, based on the result of the past handover adding operation and handover deleting operation are used. A handover candidate base station is selected based on time-sequential data about pass losses and SIR (or transmitter power level and communication quality at base stations) from a plurality of base stations, i.e., the transition of their change. Thus, since the

suitable base station can be selected, it is possible to restrain the repetition of the handover operation, control the use of unnecessary radio resources in its turn and suppress the influence of communication quality to the corresponding mobile station and other mobile stations. The use of information from connected base stations and non-connected base stations makes it possible to provide satisfactory handover even in the case of a CDMA mobile communication system connected to a plurality of base stations simultaneously.

[0008] Further, handover operating conditions are determined based on combinations of time-sequential data such as the aforementioned pass losses and SIR or pass losses and transmitter power levels, or pass losses and frame error rate (hereinafter called "FER"), etc. so that connections much than required are avoided when the state of communications with each connected base station is good. When the state of the communications with each connected base station is poor in reverse, a handover adding operation is executed earlier rather than when the state of the communications therewith is good, so that the corresponding mobile station can be connected to a plurality of base stations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention and further objects, features and advantages thereof will be better understood from the following description taken in connection with the accompanying drawings in which:

Fig. 1 shows the status of connections at handover;
Fig. 2 illustrates configurations of a base station and a base station controller;
Fig. 3A shows configurations of a control unit and a memory unit provided within the base station controller;
Fig. 3B depicts another configuration of the memory unit;
Fig. 3C shows a further configuration of the memory unit;
Fig. 4 illustrates a handover adding process;
Fig. 5 depicts a handover deleting process;
Fig. 6 is a graph for determining matching strength thresholds for handover addition/deletion;
Fig. 7 is a graph for determining AT-SIR and number-of-retries upper-limit values;
Fig. 8 shows a handover adding method at system boot-up;
Fig. 9 illustrates a handover deleting method at the system boot-up;
Fig. 10 depicts a handover adding method using a transmitter power level;
Fig. 11 shows a handover deleting method using a transmitter power level;
Fig. 12 illustrates another handover adding method at system boot-up;
Fig. 13 depicts another handover deleting method at system boot-up;
Fig. 14 shows a handover adding method using FER;
Fig. 15 illustrates handover deleting method using FER;
Fig. 16 depicts a table in which pass losses and SIR are stored;
Fig. 17 shows a table in which pass losses and transmitter power levels are stored;
Fig. 18 illustrates a table in which pass losses and FER are stored;
Fig. 19 depicts handover adding reference tables in which pass losses and SIR are stored;
Fig. 20 shows handover deleting reference tables in which pass losses and SIR are stored;
Fig. 21 illustrates handover adding reference tables in which pass losses and transmitter power levels are stored;
Fig. 22 depicts handover adding reference tables in which pass losses and FER are stored; and
Fig. 23 shows sector-to-sector handover reference tables.

DESCRIPTION OF THE PREFERRED EMBODIMENT

1. Best mode:

[0010] An embodiment according to the invention of the present application will hereinafter be described. Fig. 1 shows the status of connections at handover in a CDMA mobile communication system. A base station controller 101 connects base stations 102 to 104 to a mobile station 105 through radio or wireless lines. The mobile station 105 is a wireless terminal such as a portable telephone. The mobile station 105 moves on the road along a travel route and is now in the course of being connected to the base station 102. In the related art, the mobile station 105 thereafter had an unnecessary connection to the base station 104 which does not exist on the travel route of the mobile station 105. In the invention of the present application, however, the mobile station 105 smoothly performs handover without being connected to the base station 104. Incidentally, the handover at CDMA means not only switching between base stations

but also during connection. This is because upon CDMA, communications are made while a mobile station is being connected to a plurality of base stations simultaneously.

[0011] Fig. 2 shows a configuration of the base station controller 101 and configurations of the base stations 102 through 104 and mobile station 105. A transmit/receive shared unit 201 converts a signal transmitted from a base station to a mobile station to a transmitting frequency and converts a signal received from the mobile station to the original frequency. A RF unit 202 performs a diffusion process on the signal to be transmitted to the mobile station by means of codes for CDMA mobile communications and performs a reverse diffusion process on the signal reversely received by the base station by means of codes for CDMA mobile communications to thereby extract a necessary signal. A modulator-demodulator unit 203 performs modulation, demodulation and error correction control on a digital signal. A base station controller IF 204 transmits and receives a signal to and from the base station controller 101. A transmitter power level measuring unit 205 measures a transmitter power level for a communication channel, which is transmitted to the mobile station, and reports the result of measurement to a control unit 211 of the base station controller through a control unit 207. An FER measuring unit 206 measures FER of a received communication channel and reports the result of measurement to the control unit 211 of the base station controller through the control unit 207. The control unit 207 controls the operations of the RF unit 202, modulator-demodulator unit 203 and base station control device IF 204 in response to a control signal for calling control, which is sent from a control unit 217 of the mobile station or the control unit 211 of the base station controller. A base station IF 208 performs the transmission and reception of signals to and from one or a plurality of base stations. A diversity handover unit 209 effectively merges the same signals which are sent from one mobile station and have reached from the plurality of base stations and reversely allows a signal to be sent to the corresponding mobile station to be transmitted from the plurality of base stations. An exchange or switcher IF 210 transmits signals to a switcher and receives them therefrom. The control unit 211 performs the transfer of control signals for calling control to and from the control unit 217 of the mobile station, the control unit 207 of the base station or the switcher so as to control the base station IF 208, diversity handover unit 209, switcher IF 210 and memory unit 212 to be described later. The memory unit 212 retains data about mobile stations or base stations placed under the base station controller. A transmit/receive shared unit 213 converts a signal sent from the mobile station to the base station to a transmitting frequency and converts a signal received from the base station to the original frequency. A RF unit 214 performs a diffusion process on a signal to be transmitted to the base station by means of codes for CDMA mobile communications and performs a reverse diffusion process on a signal reversely received by the mobile station by means of codes for CDMA mobile communications to thereby extract a necessary signal. A modulator-demodulator unit 215 performs modulation, demodulation and error correction control on a digital signal. A SIR/pass loss measuring unit 216 measures SIR and a pass loss on a channel intended for the measurement of a level received by the mobile station. The control unit 217 controls the operations of the RF unit 214 and modulator-demodulator unit 215 in response to a control signal for calling control, which is sent from the control unit 207 of the base station or the control unit 211 of the base station controller. Incidentally, while the respective parts are basically hardware, some or all thereof may be implemented by means of software as needed.

[0012] Fig. 3A shows configurations of portions lying within the control unit and memory unit of the base station controller, which are related to the form of the invention of the present application. A control signal analyzer 301 is a circuit for analyzing the contents of a control signal for calling control, which is received from a mobile station, base station or switcher. A handover base station selector 302 is a circuit for comparing the status of communications of the mobile station and each reference table, determining whether the mobile station needs a handover operation and selecting a more suitable handover-destined base station. A radio link controller 303 is a circuit for performing the transfer of a control signal for establishing and maintaining the optimum radio status to and from the base station or mobile station. A learning part 304 is a circuit for updating each reference table stored in a reference table storage part 306 to be described later according to the status of execution of a handover operation. Incidentally, the circuits 301 through 304 may be comprised of software. A pass loss/SIR past information storage part 305 is a memory for storing pass losses of channels at which received levels are to be measured in advance, and SIR of each of the channels as time-sequential data therein. A reference table storage part 306 is a memory for storing therein reference tables used upon selection of a base station for a handover candidate. Post-learning pass losses, SIR and handover-destined base stations are stored in each reference table. Further, a pass loss/transmitter power level past information storage part 307 is a memory for storing therein pass losses of channels at which received levels are to be measured in advance, and base-station transmitter power levels for the channels as time-sequential data. A reference table storage part 308 is a memory for storing therein reference tables used upon selection of a base station for a handover candidate. Post-learning pass losses, transmitter power levels and handover-destined base stations are stored in each reference table. A pass loss/FER past information storage part 309 is a memory, which stores therein pass losses of channels intended for the measurement of received levels from each individual base stations to a mobile station being in communication, and a frame error rate of a communication channel employed in each base station as time-sequential data. The communication channel principally means a traffic channel but may be another channel if one capable of measuring the quality of a communication line is used. A reference table storage part 310 is a memory for storing therein each reference

table compared with the time-sequential data stored in the pass loss/FER past information storage part 309 upon selection of the base station for the handover candidate.

[0013] The operations of the base stations 102 through 104 and base station controller 101 shown in Fig. 2 will first be described. The base stations 102 through 104 respectively transmit pilot channels used as indexes for soft handover and power control through the use of the transmit/receive shared units 201. Incidentally, the pilot channel might be also called by another name such as a perch channel according to the difference in standard specification. The base station 102 being connected to the mobile station 105 transmits user information such as voice, data through the use of a traffic channel. The mobile station 105 having received the corresponding pilot channel measures signal quality such as its pass loss, SIR or the like and reports the result of measurement to the base station controller 101 through the base station 102 in connection. Incidentally, the mobile station 105 receives even pilot channels of the non-connected base stations 103 and 104 as well as that of the base station 102 now in connection and reports their signal quality to the base station controller 101. Further, the base station 102 in connection receives an uplink traffic channel from the mobile station 105, measures its signal quality, and reports the result of measurement thereof to the base station controller 101. While the signal quality is defined as FER in the present embodiment, another signal quality such as BER may be used.

[0014] The operations of the base station and base station controller will now be described in little more details. A signal sent from the mobile station 105 is received by the transmit/receive shared unit 201 of the base station 102. After the signal has passed through the modulator-demodulator unit 203, it is transmitted to the base station controller 101 through the base station controller IF 204. The signal sent to the base station controller 101 is received through the base station IF 208 and sent to the control unit 211 provided within the base station controller 101 through the diversity handover unit. The transmission of a downlink signal from the base station controller 101 to the mobile station 105 results in the inverse of the above-described path. Instructions issued from the base station controller 101 to the base stations 102 through 104 are transmitted from the control unit 211 and reaches the control units 207 provided within the base stations 102 through 104 through the base station IF 208 and bas station controller IF 204. The transmission of the signals from the base stations 102 through 104 to the base station controller 101 results in the inverse of the above-described path. In the control unit 211 in the base station controller 101, the control signal analyzer 301 determines the type of each of the control signals transmitted from the mobile station 105 and base stations 102 through 104. When the control signals are regarded as reports such as pass losses and SIR transmitted from the mobile station 105, of channels for the measurement of received levels from the already-connected base station 102 and non-connected peripheral base stations 103 and 104, the handover base station selector 302 starts up a handover process. The radio link controller 303 transmits a request for addition to handover or deletion from handover to the base station 103 selected by the handover base station selector 302 and the corresponding mobile station 105.

[0015] When the handover addition or deletion is carried out, the learning part 304 updates reference data by using the result thereof and past information about pass losses and SIR. Specific handover processes will be disclosed below.

(1) Handover adding process:

[0016] Fig. 4 shows a flowchart for describing a handover adding operation of a control unit. In the present embodiment, the base station controller 101 selects a suitable additional candidate, based on each of matching-orientated tables and each of reference tables to thereby control unnecessary handover adding operations. Here, the matching-orientated table means a table reported from the mobile station 105, in which transitions of changes in pass loss and SIR about the already-connected base station and non-connected peripheral base stations 103 and 104 are stored. On the other hand, the reference table indicates a table in which transitions of changes in pass loss and SIR and results of learning of bases stations destined for handover addition are stored. Further, the additional candidate indicates a candidate of a base station to be added to handover.

[0017] Incidentally, suffixes m, p, p' are used for purposes of generalized illustration. m is a number indicative of a mobile station in communication. p is a number indicative of each base station being in communication with the mobile station. p' is a number indicative of each base station non-connected to the mobile station. A mobile station m(105) creates $L_m(t)$ indicative of signal quality at a time t by means of a control unit thereof and transmits the created $L_m(t)$ to the connected base station 102. $L_m(t)$ includes a pass loss ($l_{m,p}(t)$) and SIR ($S_{m,p}(t)$) of a pilot channel transmitted from a connected base station p(102), and a pass loss ($l_{m,p'}(t)$) and SIR ($S_{m,p'}(t)$) of a pilot channel transmitted from each of non-connected base stations p'(103 and 104). Described more specifically, $L_m(t) = \{(l_{m,p}(t), S_{m,p}(t)), (l_{m,p'}(t), S_{m,p'}(t)), \ldots\}$. Incidentally, the mobile station 105 may adopt channels other than the pilot channels as objects for the measurement of received levels. While the base station 102 receives $L_m(t)$ therein, it measures FER ($Fer_{m,p}(t)$) of an uplink traffic channel and transmits $L_m(t)$ and $Fer_{m,p}(t)$ to the corresponding base station controller.

[0018] The handover base station selector 302 receives $L_m(t)$ and $Fer_{m,p}(t)$ through the control signal analyzer 301. The control unit 211 determines the transition of a change in $L_m(t)$ from the received signal quality information $L_m(t)$ to thereby create a matching-orientated table U_m1701 indicative of the transition of a change in received quality and

stores it in the pass loss/SIR past information storage part 305. Incidentally, U_m will be expressed as $U_m = u[L_m(t-n), L_m(t)]$.

[0019] Fig. 16 shows an example of the matching-orientated table U_m. Information about pass losses and SIR of pilot channels extracted from $L_m(t)$, and FER($Fer_{m,p}(t)$) of an uplink traffic channel measured by the connected base station 102 are stored in U_m1701 as time-sequential data at times $_{t-n\,to\,t}$. In the present example, the pass loss $L_{m,102}(t)$ of the base station 102 is given as 10 and SIR ($S_{m,102}(t)$) thereof is stored as 12. Incidentally, $Fer_{m,102}(t)$ is given as 30. In the example shown in Fig. 16, the base station 102 is set as the connected base station p, and the base stations 103 and 104 result in non-connected base stations p'. When a mobile station is already connected to a plurality of base stations, a plurality of connected base stations p exist. At this time, however, the connected base stations brought to the minimum pass loss or maximum SIR will be defined as p. A plurality of base stations each having a threshold or greater or a few upper stations good in quality may be defined as p.

[0020] After the matching-oriented table and the reference table are matched with each other, a matching strength threshold is updated based on the amount of change in FER of the traffic channel. Since the matching strength threshold is one which has taken into consideration communication quality of each connected base station, it is effective in exerting control on an unnecessary handover adding operation.

[0021] In Step 401, the handover base station selector 302 first refers to a matching-orientated table U_m. In Step 402, the handover base station selector 302 calculates the amount of change D_p in $L_{m,p}(t)$ of a connected base station BTS_p within a unit time n (time $_{t-n\,to\,t}$) and the amount of change D_{fer} in FER of the traffic channel from the following equations:

$$D_p = d[L_{m,p}(t-n), L_{m,p}(t)]$$
$$= L_{m,p}(t) + |L_{m,p}(t) - L_{m,p}(t-n)|/n$$
$$= (L_{m,p}(t) + |L_{m,p}(t) - L_{m,p}(t-n)|/n)$$

$$D_{fer} = d[Fer_{m,p}(t-n), Fer_{m,p}(t)]$$
$$= Fer_{m,p}(t) + (Fer_{m,p}(t) - Fer_{m,p}(t-n))/n$$

[0022] When the time interval n is defined as 16 in the table shown in Fig. 16, for example, D_p results in (10 + (10-2) /10) = 10.8 and D_{fer} is determined as (30 + (30-0/10) = 33.3. The handover base station selector 302 determines a matching strength threshold TH_{match} = thre (D_p,D_{fer}) by using D_p and D_{fer} referred to above. The matching strength threshold is a value used as an index upon adding a handover base station. The thre() is a function for determining TH_{match} from D_p and D_{fer}. The thre() may be a function having the following feature. As to the thre(), TH_{match} may preferably be set high relatively when the amount of change D_p in pass loss and SIR and the amount of change D_{fer} in FER are small. This is because when the state of a connected communication channel is stable and the communication channel is high in quality, it is capable of sufficiently communication even without daringly performing handover. On the other hand, when the amount of change D_p in pass loss and SIR and the amount of change D_{fer} in FER are large, TH_{match} may preferably be set low relatively as the thre(). This is done to make it easy to perform the handover adding operation when the state of a connected communication channel is unstable and the quality of communications is degraded. Incidentally, when FER is suddenly degraded, TH_{match} is relatively set low in consideration of even the transition of change in FER of each connected base station. If done in this way, then the base stations result in handover adding candidate base stations even if the matching strength is strong. Therefore, the mobile station can be connected to a plurality of base stations in a stage faster than as usual.

[0023] One example of a method of determining TH_{match} referred to above is shown in a graph of Fig. 6. In Fig. 6, the state of each connected communication channel is determined from the sum of D_p and D_{fer} to thereby determine TH_{match}. If TH_{match} is actually determined from Figs. 16 and 6, then the amount of change D_p in pass loss and SIR and the amount of change D_{fer} in FER become 10.8 and 33.3 respectively and hence TH_{match} results in TH_{match} = thre (10.8,33.3) = about 0.5.

[0024] In Step 403, the handover base station selector 302 successively compares a plurality of reference tables U_i and matching-orientated tables U_m to determine their matching strengths ST_i and determines the maximum matching strength ST_{max} of them. This is because if sufficient learning has already been performed, the optimum handover candidate would be obtained as one maximum in matching strength, of a plurality of past handover destinations. The

handover base station selector 302 refers to the reference tables $U_i = [U_i(0), U_i(1), \ldots U_i(n)]$ $(0 \leq i < k$, where k indicates the number of reference tables for handover addition). The tables U_i are pre-learned time-sequential data about pass losses and SIR of channels for the measurement of received levels at a mobile station and are stored in the reference table storage part 306 of the memory unit 212. $U_i(0)$ through $U_i(n)$ indicate respective components at times 0 through n of the reference tables U_i respectively. An example illustrative of the tables U_i is shown in Fig. 19. In Fig. 19, U_0 is expressed

as[(1,20,10,6,8,8),(1,18,10,8,7,7)

...(8,5,2,19,9,6)].

[0025] The maximum matching strength ST_{add} is next calculated. In order to calculate ST_{add}, it is necessary to match U_m and a plurality of U_i with one another respectively and determine their matching strengths ST_i. Examples of methods of matching U_i with U_m will now be introduced. One example is a method of firstly extracting a base station registered in U_m, selecting U_i in which each base station extracted from a plurality of reference tables is registered, and matching them with each other. Another example is a method of firstly normalizing a table size so that U_m coincides with the number of base stations registered in tables of U_i and matching U_m with U_i.

[0026] The matching strengths ST_i between U_m and U_i $(0 \leq i < k)$ can be obtained from the following equation:

ST_i = 1 - (difference at a time 0 + difference at a time 1 + ... + difference at a time n)/n

[0027] Thus, the matching strengths ST_i between U_m and k U_i are respectively determined, and one having the maximum value of the k ST_i will be defined as ST_{add}. Incidentally, when a plurality of base stations are added simultaneously, those each having a threshold or higher or several upper stations good in quality may be selected.

[0028] In Step 404, the handover base station selector 302 makes a decision as to whether ST_{add} is greater than or equal to TH_{match}. If ST_{add} is found to be greater than or equal to TH_{match}, then the handover base station selector 302 proceeds to Step 405. In Step 405, the handover base station selector 302 selects an addition-destined base station BTS_i in an ith reference table chosen as ST_{add} as an additional candidate. In the previously-determined example, TH_{match} is set as 0.5. Assuming that the matching strength ST_0 between U_m and U_0, of the previously-determined ST_i is maximum and ST_0 = 0.7, BTS103 recorded in U_i is selected as an additional candidate to meet the condition of $ST_{add} > TH_{match}$.

[0029] Next, in Step 406, the base station controller determines the difference in pass loss and SIR between a connected base station p and an additional candidate base station i and determines a target SIR at the addition of handover, the number of retries at a handover adding operation and handover deletion/addition conditions according to the difference. In the present embodiment, unnecessary deletions are lessened by varying the above-described target SIR, number of retries and addition conditions according to the status of communications.

[0030] Here, the term target SIR indicates an index of reception quality to be met when an uplink signal transmitted from a mobile station m is received by its corresponding base station.

[0031] Further, the addition conditions used upon handover deletion may include a handover addition hysteresis, a grace time interval and the number of graces. The handover addition hysteresis is a kind of threshold and corresponds to one in which when the time between adding a given base station to handover and next bringing it to a deletion candidate does not exceed the threshold, the deletion from the handover is not recognized. The grace time interval corresponds to a time interval required to allow of deletion even if a matching strength threshold falls short of a deleted threshold continuously for a predetermined time interval. Namely, the base station becomes a deleted candidate only when the time interval having fallen short of the threshold continuously exceeds the grace time interval. The number of graces corresponds to the number of times in which the deletion is allowed even if the matching strength threshold falls short of a handover deletion threshold within a unit time several times. Namely, it would become a deleted candidate only when having exceeded the number of graces referred to above. Owing to these, the base station added to the handover is set so as not to be deleted from the handover immediately after the addition thereof.

[0032] The radio link controller 303 calculates the difference between $L_{m,i}(t)$ about an added candidate base station i(103) and $L_{m,p}(t)$ about a base station p(102) connected now and placed during communications, of $L_m(t)$ reported from a mobile station m(105). The radio link controller 303 determines ΔT-SIR from the difference. ΔT-SIR is a value for temporarily increasing T-SIR corresponding to the present target SIR upon the handover adding operation.

$$\Delta T\text{-}SIR = Sir(L_{m,i}(t) - L_{m,p}(t))$$

$$= Sir(l_{m,i}(t) - l_{m,p}(t))$$

Further, a number-of-retries upper limit value N_{retry} at the time of a failure in handover adding operation is determined

from the difference

$$N_{retry} = Retry(L_{m,i}(t) - L_{m,p}(t))$$

$$= Retry(l_{m,i}(t) - l_{m,p}(t))$$

where Sir() and Retry() are functions for determining ΔT-SIR and N_{retry} from the difference between $L_{m,i}(t)$ and $L_{m,p}(t)$, respectively. When the difference between $L_{m,i}(t)$ and $L_{m,p}(t)$ is large, it is desirable that ΔT-SIR is made great to increase the output of the mobile station a little bit and the number of retries N_{retry} is also increased. This is because since the distance between the mobile station and the handover additional candidate base station i is considered to increase when the difference between $L_{m,i}(t)$ and $L_{m,p}(t)$ is large, a transmitter power level increases to make it easy to succeed in handover and it is necessary to make retries several times even if the handover adding operation ends in failure. Since the distance between the mobile station and the additional candidate base station i decreases when the difference between $L_{m,i}(t)$ and $L_{m,p}(t)$ is determined to be small in reverse, it can be said that this would become a situation easy to succeed in handover adding operation. It is thus desirable that ΔT-SIR is reduced to avoid the consumption of resources and N_{retry} is reduced so that even the number of retries at the time of the failure in handover adding operation is decreased. When the difference between $L_{m,i}(t)$ and $L_{m,p}(t)$ is large, it can be also said that the handover additional candidate base station i is easy to become a handover deletion candidate after the addition of handover.

[0033] Fig. 7 shows one example of a method of determining respective conditions. Determining both from the example shown in Fig. 16 yields ΔT-SIR = $Sir(L_{m,i}(t) - L_{m,p}(t)) = Sir(2 - 10) = Sir(-8) = 0.1$ and $N_{retry} = Retry(l_{m,i}(t) - l_{m,p}(t)) = Retry(2 - 10) = Retry(-8) = 1$.

[0034] Further, the radio link controller 303 determines a hysteresis T_{del} for defining the connection of a base station i(103) thereto as a deleted candidate after the completion of the handover adding operation from the difference between $L_{m,i}(t)$ and $L_{m,p}(t)$. T_{del} may preferably be set longer as the difference between $L_{m,i}(t)$ and $L_{m,p}(t)$ becomes large, in order to prevent the repetition of a process for adding handover or a process for deleting it.

[0035] In Step 407, the radio link controller 302 initializes a counter N_{count} for counting the number of times that the handover adding operation is retried. In Step 408, the radio link controller 303 instructs the mobile station m and the handover additional candidate base station BTS_i to execute the handover adding operation. In Step 409, the radio link controller 303 counts up the value of N_{count}.

[0036] After the handover addition executing instructions have been made in Steps 407 through 409, the radio link controller 303 makes a decision as to the result of the handover adding operation in Step 410. If the handover adding operation succeeds at the mobile station m and the handover additional candidate base station i, then the radio link controller 303 proceeds to Step 413. If the handover adding operation has failed at the mobile station m or the base station i, then the radio link controller 303 proceeds to Step 411. If the retry counter N_{count} reaches greater than or equal to the number-of-retries upper limit value N_{retry} at this time, then the radio link controller 303 proceeds to Step 412 for the learning part 304. If less than or equal to N_{retry}, then the radio link controller 303 returns to Step 408, from which the handover adding operation is repeated.

[0037] Next, in the present embodiment, when the handover adding operation has failed, the reference tables U_i are updated so that the corresponding base station becomes hard to do the handover adding operation in the case of the transition of a change in pass loss/SIR at its failure. On the other hand, when the handover adding operation has succeeded, the reference tables U_i are updated so that the corresponding base station becomes easy to do the handover adding operation as the number of retries at that time decreases. A weighting factor W is used for updating. Incidentally, W assumes the value between $-1 \leq W \leq 1$. The values of respective components $U_i(0)$ through $U_i(n)$ of each reference table U_i are updated so that the base station i failed in addition becomes hard to be next taken as an additional candidate, as W takes a negative large value. On the other hand, as W takes a positive large value, the values thereof are updated so that the base station i is easy to become an additional candidate.

[0038] When the handover adding operation is found to have failed in Step 410, the radio link controller 303 proceeds to Step 411. When N_{count} reaches a value greater than or equal to N_{retry} in Step 411, it means the exceeding of the limit of a failure. Therefore, the learning part 304 multiplies the difference $\{L_m(t-n)- U_i(0), L_m(t-n+1) - U_i(1), \ldots, L_m(t) - U_i(n)\}$ between U_m and U_i by -1 as the weighting factor W in Step 412 and updates $U_i = \{U_i(0), U_i(1), \ldots U_i(n)\}$ next time so as to avoid an additional candidate. An example of calculations thereof will now be explained. If U_0 is defined as a pre-updating value and U_0' is defined as a post-updating value, then the calculation is performed as in the case of $U_0' = \{U_0'(0), U_0'(1), \ldots U_0'(n)\} = \{U_0(0) + (-1)x(L_m(t-n) - U_0(0)), \ldots, U_0(n) + (-1)x(L_m(t)- U_0(n))\}$. In the examples shown in Figs. 16 and 18, $U_0'(0)$ is updated as $U_0'(0) = \{(1-(2-1)),(20-(20-20)),(10-(10-10)),(6-(6-6)),(8-(7-8)),(8-(7-8))\} = \{0,20,10,6,9,9\}$. When this is done until $U_0(0)$ through $U_0(n)$, the updating of the reference table U_0 is completed.

[0039] When the handover adding operation is found to have succeeded in Step 410, the learning part 304 sets the

weighting factor W as a large value as the number of the retries decreases in Step 413. When the weighting factor W is determined in this way, the reference table is updated so that the corresponding base station at U_m is easy to become an additional candidate as the number of the retries decreases.

[0040] In Step 414, the learning part 304 multiplies the difference between U_m and U_i by W to thereby update the values of $U_i(0)$ through $U_i(n)$ of U_i. Assuming that as a result of selection of BTS103 as an additional candidate base station from the reference table U_0 and a trial of the handover adding operation in the previous example, the handover adding operation has succeeded at $N_{count} = 1$ and $W = Weight(1) = 0.8$, the reference table U_0 is updated as $U_0' = [U_0'(0), U_0'(1), \ldots, U_0'(n)] = [U_0(0) + \{-0.8x(L_m(t-n) - U_0(0)), \ldots, U_0(n) + \{-0.8x(L_m(t) - U_0(n))\}]$. In the examples shown in Figs. 16 and 18, U_0 is updated as in the case of $U_0'(0) = [\{1 + 0.8x(2 - 1)\}, \{20 + 0.8x(20 - 20)\}, \{10 + 0.8x(10 - 10)\}, \{6 + 0.8x(6 - 6)\}, \{8 + 0.8x(7 - 8)\}, \{8 + 0.8x(7 - 8)\}] = [1.8, 20, 10, 6, 7.2, 7.2]$. When this is done until $U_0'(0)$ through $U_0'(n)$, the renewal of the reference table U_0 is completed.

[0041] Next, in the present embodiment, when each base station added by handover is deleted in a short time after the addition thereof, the reference tables U_i are updated so that the base station is not added in the case of the transition of a change in pass loss and SIR at that time. Thus, the repetition of unnecessary handover adding and deleting operations is controlled.

[0042] When the radio link controller 303 detects in Step 415 that the base station i is brought to a handover deleted or deletion candidate in t (where $t \leq T$, where T indicates upper-limit time required to monitor the deleting operation) seconds after the handover adding operation has succeeded, the learning part 304 determines a weighting factor -W in Step 416 so that the weighting factor -W becomes a negative large value as the time t becomes short. By determining the weighting factor -W in this way, the reference tables U_i are updated so that the corresponding base station is hard to become an additional candidate as the time t becomes short. In Step 417, the learning part 304 multiplies the difference between U_m and U_i by the weighting factor -W to thereby update the reference tables U_i.

(2) Handover deleting process:

[0043] Fig. 5 shows a flowchart for describing a handover deleting process.

[0044] The base station controller 101 learns the result of the handover deleting process in a manner similar to the method of selecting the candidate for each base station to be added to the handover. A base station regarded as a deleted candidate from handover is selected based on the learned reference table, whereby the repetition of deleting and adding processes is avoided and needless use of radio resources is controlled.

[0045] The handover base station selector 302 receives a report $L_m(t)$ about pass losses and SIR from the mobile station m through the control signal analyzer 301. In Step 501, the handover base station selector 302 refers to the pass loss/SIR past information storage part 305 to thereby obtain $U_m = u[L_m(t-n), L_m(t)]$ indicative of the transition of a change in $L_m(t)$. Fig. 16 shows an example of a matching-orientated table U_m.

[0046] In the present embodiment, a matching strength threshold is varied based on pass losses, SIR and FER of a base station brought to the minimum pass loss or maximum SIR, of connected base stations in order to control unnecessary deleting operations.

[0047] In Step 502, the handover base station selector 302 selects a base station q (where q: natural number) brought to the minimum pass loss or maximum SIR, of connected based stations in $L_m(t)$ and calculates the amount of change $D_q = d[L_{m,q}(t-n), L_{m,q}(t)]$ in values $L_{m,q}(t)$ of a pass loss and SIR of the base station q, per unit time ($time_{t-n \leq t}$). Further, the handover base station selector 302 calculates the amount of change $D_{fer} = d[Fer_{m,q}(t-n), Fer_{m,q}(t)]$ in FER with respect to a mobile station m, which has been measured by the base station q. In the example of Fig. 18, BTS102 is defined as the base station q. The handover base station selector 302 determines a matching strength threshold $TH_{match}' = thre'(D_q, D_{fer})$ used upon execution of matching with handover deleting reference data through the use of D_q and D_{fer}. Here, thre'() is a function for determining the matching strength threshold TH_{match}' for handover deletion from D_q and D_{fer}. One example of a method of determining TH_{match}' is shown in a graph of Fig. 6. The drawing shows that thre'() meets the following features. Namely, when the amount of change in pass loss and SIR D_q and the amount of change in FER D_{fer} are small, thre'() provides a relatively low value as TH_{match}'. This is because when each connected communication channel is stable in state and high in quality, a connection to unnecessary base stations becomes easy to be released. When the amount of change in pass loss and SIR D_q and the amount of change in FER D_{fer} are great in reverse, i.e., when the state of each connected communication channel is unstable and communication quality is degraded, thre'() provides a relatively high value as TH_{match}' so that a connection to a plurality of base stations becomes hard to be set free.

[0048] In Step 503, the handover base station selector 302 refers to reference tables U_j ($0 \leq j < 1$, where 1 indicates the number of reference tables for handover deletion) in which respective transitions of changes in pass loss and SIR of channels intended for the measurement of received levels and handover deletion-destined base stations have been written. The handover base station selector 302 matches U_j and U_m with one another to calculate the maximum matching strength ST_{del}. Incidentally, when a plurality of base stations are deleted simultaneously, a plurality of base stations

each having one exceeding a threshold or poor in quality may be selected. An embodiment illustrative of U_j tables is shown in Fig. 20. Pass losses and SIR reported from mobile stations are stored in the tables as learned time-sequential data. U_j are stored in the reference table storage part 306. Two examples illustrative of methods of matching U_j with U_m will now be introduced. One example is a method of extracting a base station registered in the tables of U_m in Fig. 16, selecting a table in which each extracted base station is registered, out of a plurality of U_j tables, and matching U_j and U_m with each other. Another example is a method of normalizing a table size so that U_m tables coincide with the number of base stations registered in the tables of U_j and matching U_m with the plurality of U_j.

[0049] In Step 504, the handover base station selector 302 makes a decision as to whether the maximum matching strength ST_{del} is greater than or equal to a matching strength threshold TH_{match}. If ST_{del} is found to be grater than or equal to the matching strength, then the handover base station selector 302 proceeds to Step 505, where it selects a deletion-destined base station j written in a jth handover deleting reference table as a deleted candidate.

[0050] In Step 506, the radio link controller 303 calculates the difference between a value $L_{m,j}(t)$ from the handover deletion-destined candidate base station j and a value $L_{m,q}(t)$ from a base station BTS_q assuming the minimum pass loss or maximum SIR, of base stations being now connected and in communication, both of which are selected out of reports $L_m(t)$ about pass losses and SIR of channels for the measurement of received levels, which have been reported from a mobile station m. In the present embodiment, the base station controller updates a handover deletion hysteresis or handover addition applying condition, based on the differences between pass losses and SIR of a handover deletion candidate base station and pass losses and SIR of each connected base station brought to the minimum pass loss or maximum SIR. The hysteresis indicates a grace time for avoiding the treatment of each base station deleted from handover as a handover additional candidate soon again. The handover addition applying condition corresponds to a condition for setting a base station j as an additional candidate again after having been deleted from handover. This indicates the number of times that a matching strength exceeds a handover addition threshold within a unit time or a time interval during which the matching strength exceeds a threshold continuously. Owing to these, the handover deletion and re-addition erroneously carried out when the quality of communications with each connected base station is good, are prevented.

[0051] It is desirable that in order to prevent the repetition of the handover deleting/adding operation, a handover addition applying condition T_{add} is set long as the difference between $L_{m,q}(t)$ and $L_{m,j}(t)$ becomes small. This is because when the difference between $L_{m,q}(t)$ and $L_{m,j}(t)$ is small, a handover deletion candidate base station j is apt to become an additional candidate immediately after its deletion and the unnecessary repetition of the deleting and adding operations might occur.

[0052] In Step 507, the radio link controller 303 instructs the mobile station m and handover deletion candidate base station j to execute the deleting process from the handover. The thus-instructed mobile station m and base station j performs the handover deleting process.

[0053] In Step 508, the radio link controller 303 makes a decision as to the result of the handover deleting operation. If the handover deleting operation succeeds at the mobile station m and the handover deletion candidate base station j, then the radio link controller 303 proceeds to Step 509. The learning part 304 multiplies the difference between U_m and U_j by 1 as a weighting factor W' to update the handover deleting reference table U_j. The weighting factor at this time takes a value between $-1 \leq W' \leq 1$. The learning part 304 updates the corresponding reference table so that the base station j becomes hard to be a deleted candidate as the weighting factor W' takes a negative large value. On the one hand, the learning part 304 updates the corresponding reference table so that as the weighting factor W' takes a positive large value, the base station j is easy to become a deleted candidate.

[0054] Steps 510 through 512 are steps for controlling the unnecessary repetition of the deleting and adding processes when a given base station becomes an addition candidate immediately after its deletion. When the radio link controller 303 first detects in Step 510 that a base station BTS_j has been brought to a handover addition candidate in t' ($\leq T'$: T': adding operation monitoring upper-limit time) seconds after the base station BTS_j has succeeded the handover deleting operation, it proceeds to Step 511. The radio link controller 303 determines a weighting factor -W' so that the weighting factor -W' becomes a negative large value as the time t' becomes short. In Step 512, the learning part 304 multiplies the difference between U_m and U_j by the weighting factor -W' to update the reference table U_j.

(3) Handover adding process at the beginning of system boot-up:

[0055] Fig. 8 shows a handover adding process at the beginning of system boot-up.

[0056] The memory unit 212 at the beginning of system boot-up does not register therein reference tables corresponding to the number enough to carry out the aforementioned embodiment. As a result, the matching strength becomes less than the matching strength threshold, thus causing the events that handover cannot be suitably carried out. Although data may be collected in advance before the provision of service, a human investment cannot be neglected either as well as expenditures of a long time upon collection of sufficient data. Enterprisers for provision of service desire to avoid such waste if practicable.

[0057] Thus, in the present embodiment, the learning-type first handover mode described up to now and a second handover mode used for the system boot-up are used by switching. Owing to their use, more suitable handover is provided even in the case of the beginning of the system boot-up.

[0058] In the second handover mode, pass losses and SIR of each non-connected base station are first respectively compared with a fixed handover additional threshold. If a base station having one sufficiently exceeding the threshold exists, then the base station is added to handover. After the execution of handover based on the fixed threshold, the transition of a change in pass loss and SIR at this time is then multiplied by a weighting factor corresponding to the success/failure of the execution of handover, which in turn is newly registered in the corresponding reference table. Thus, although a reference table is not created in advance upon system boot-up, the reference table is automatically created simultaneously with its boot-up.

[0059] In Step 403, the handover base station selector 302 matches handover adding reference tables U_i and matching-orientated tables U_m with one another to thereby calculate the maximum matching strength ST_{add}. When it is found in Step 404 that the maximum matching strength ST_{add} is less than the matching strength threshold TH_{match}, the handover base station selector 302 proceeds to Step 801, where the handover base station selector 302 examines the number of handover adding reference tables N_{add_table} registered in the reference table storage part 306 of the memory unit 212.

[0060] When the number of the reference tables N_{add_table} is less than a lower-limit value a of the registered number of tables as a result of the examination of N_{add_table} in Step 801, the handover base station selector 302 determines that the sufficient learning of handover adding operation is not performed and the number of the handover adding reference tables is insufficient. Thereafter, the handover base station selector 302 proceeds to Step 802 to carry out the normal handover adding operation. Incidentally, the lower-limit value a indicates the allowable minimum number of tables and may be determined according to simulation or experiences.

[0061] In Step 802, the handover base station selector 302 initializes a variable i used upon detecting $L_m(i)$ according to base stations. Thereafter, the handover base station selector 302 examines in Step 803 whether values $L_{m,i}(i)$ ($0 \leq i < N_m$. N_m indicates the number of base stations, which is reported from a mobile station) reported according to base stations of $L_m(i)$ exceed a handover additional threshold TH_{add} in the second mode.

[0062] When $L_{m,i}(i)$ greater than TH_{add} is obtained in Step 803, the handover base station selector 302 refers even to the past reported values in Step 804 to obtain a time T_{over} during which $L_{m,i}(i)$ is over a threshold TH_{add} continuously. When it is determined in Step 805 that the time T_{over} is above a threshold T_{over_TH}, the handover base station selector 302 selects a base station i of $L_{m,i}(i)$ as a handover addition candidate base station in Step 806 and proceeds to Step 406.

[0063] Incidentally, these Steps are effective when reference tables are normally few in number as well as at the beginning of the system boot-up.

(3) Handover deleting process at the beginning of system boot-up:

[0064] Fig. 9 shows a handover deleting process at the beginning of system boot-up. In the invention of the present application, the shortage of matching strength produced due to the fact that the registered number of reference tables at the beginning of system boot-up or the like is insufficient, is solved by a two-mode handover method in a manner similar to the time when handover is added. Namely, the handover deleting method disclosed in Fig. 5 is used as a first mode and a method to be described later is used as a second mode.

[0065] In Step 603, the handover base station selector 302 matches U_i with U_m to calculate the maximum matching strength ST_{del}. Thereafter, when the handover base station selector 302 determines in Step 604 that the maximum matching strength ST_{del} is less than the matching threshold TH_{match}, it examines the number of handover deleting reference tables $N_{del\ table}$ registered in the reference table storage part 306 of the memory unit 212.

[0066] When the number of the reference tables $N_{del\ table}$ is less than a lower-limit value b of the registered number of tables as a result of the examination of $N_{del\ table}$ in Step 901, the handover base station selector 302 determines that the sufficient learning of handover deleting operation is not performed and the number of the handover deleting reference tables is insufficient, and executes the second mode subsequent to Step 902. Incidentally, the lower-limit value b indicates the allowable minimum number of tables and may be determined according to simulation or experiences.

[0067] In Step 902, the handover base station selector 302 initializes a variable for detecting values $L_m(i)$ of pass losses and SIR reported from a mobile station m according to base stations. Thereafter, the handover base station selector 302 examines in Step 903 whether values $L_{m,i}(i)$ reported according to base stations are less than a handover deletion threshold TH_{del} in the second mode.

[0068] When $L_{m,i}(i)$ less than TH_{del} is obtained in Step 903, the handover base station selector 302 refers even to the past reported values in Step 904 to obtain a time T_{under} during which $L_{m,i}(i)$ is under the threshold TH_{del} continuously. When it is determined in Step 905 that the time T_{under} is above a threshold T_{under_TH}, the handover base station selector

302 selects a base station j of $L_{m,j}(t)$ as a handover deletion candidate base station and proceeds to Step 506.

2. Second embodiment:

(1) Handover adding process

[0069] Another embodiment according to the invention of the present application will hereinafter be described using Figs. 10 and 38 and the like. In the second embodiment, a transmitter power level set for a communication channel transmitted by a base station is used instead of the aforementioned SIR.

[0070] Fig. 10 shows another embodiment using a handover adding process. A mobile station m measures a pass loss of a pilot channel transmitted by a connected base station and a pass loss of a pilot channel transmitted by a non-connected base station at a time t and reports the result of measurement $L_m(t)$ to a base station controller through the connected base station. Further, the connected base station reports a transmitter power level $P_m(t)$ for the traffic channel transmitted to the mobile station m to the base station controller. A handover base station selector 302 receives $L_m(t)$ and $P_m(t)$ through a control signal analyzer 301. In Step 1101, the handover base station selector 302 determines a change transition $Ui_m = u[L_m(t-n),L_m(t)]$ from pass losses $L_m(t-n)$ to $L_m(t)$ and a change transition $Up_m = u[P_m(t-n),P_m(t)]$ from transmitter power levels $P_m(t-n)$ to $P_m(t)$. The handover base station selector 302 stores Ui_m and Up_m in a pass loss/transmitter power level past information storage part 307. The handover base station selector 302 creates a matching-orientated table $U_m = [Ui_m,Up_m]$ from Ui_m and Up_m and stores it in the pass loss/transmitter power level past information storage part 307. Fig. 17 shows an example of U_m. U_m has pass losses of pilot channels reported by mobile stations, transmitter power levels of traffic channels transmitted by connected base stations, and FER of each uplink traffic channel as time-sequential data at times $_{t-n\ to\ t}$.

[0071] In Step 1102, the handover base station selector 302 selects a base station BTS_p which minimizes the pass loss of the pilot channel, from a plurality of connected base stations. Continuously, the handover base station selector 302 calculates the amount of change $D_p' = d[P_{m,p}(t-n),P_{m,p}(t)]$ in transmitter power level $P_{m,p}(t)$ of traffic channel transmitted from BTS_p to the mobile station m within a unit time (times $_{t-n\ to\ t}$). Further, the handover base station selector 302 calculates the amount of change $D_{fer} = d[Fer_{m,p}(t-n),Fer_{m,p}(t)]$ in FER of uplink traffic channel measured by BTS_p at the times $_{t-n\ to\ n}$. The handover base station selector 302 determines a matching strength threshold $TH_{match} = thre(D_p',D_{fer})$ using D_p' and D_{fer} referred to above. As a method of determining TH_{match}, the same method as the aforementioned handover adding process may be adopted.

[0072] In Step 1103, the handover base station selector 302 matches handover adding reference tables U_i and U_m with one another to thereby calculate the maximum matching strength ST_{add}. Fig. 21 shows an embodiment illustrative of U_i. A reference table storage part 308 stores U_i as the past result of learning. U_i includes a transition $Ui_i = u[L_i(0),L_i(n)]$ of a change in pass loss $L_i(t)$, a transition $Up_i = u[P_i(0),P_i(n)]$ of a change in transmitter power level $P_i(t)$, and handover addition-destined base stations at that time. U_i is stored in the reference table storage part 308.

[0073] After the calculation of ST_{add} in Step 1103, the handover base station selector 302 proceeds to Step 404. The subsequent processes are similar to the best mode.

(2) Handover deleting process:

[0074] Fig. 11 shows an embodiment of another handover deleting process. In the present embodiment, a transition of a change in transmitter power level of downlink traffic channel is used in place of the transition of change in SIR.

[0075] In Step 1201, the handover base station selector 302 determines a transition $Ui_m = u[L_m(t-n),L_m(t)]$ of a change from pass losses $L_m(t-n)$ to $L_m(t)$, and a transition $Up_m = u[P_m(t-n),P_m(t)]$ of a change from transmitter power levels $P_m(t-n)$ to $P_m(t)$. The handover base station selector 302 stores Ui_m and Up_m in the pass loss/transmitter power level past information storage part 307. The handover base station selector 302 creates a matching-orientated table $U_m = [Ui_m,Up_m]$ from Ui_m and Up_m and stores it in the pass loss/transmitter power level past information storage part 307. An example illustrative of U_m is shown in Fig. 17.

[0076] In Step 1202, the handover base station selector 302 selects a base station BTS_q which minimizes a pass loss of a pilot channel, from a plurality of connected base stations. Continuously, the handover base station selector 302 calculates the amount of change $D_q' = d[P_{m,q}(t-n),P_{m,q}(t)]$ in transmitter power level $P_{m,q}(t)$ of traffic channel transmitted from BTS_q to the mobile station m within a unit time (times $_{t-n\ to\ t}$). Further, the handover base station selector 302 calculates the amount of change $D_{fer} = d[Fer_{m,q}(t-n),Fer_{m,q}(t)]$ in FER of uplink traffic channel measured by BTS_q at the times $_{t-n\ to\ n}$. The handover base station selector 302 determines a matching strength threshold $TH_{match}' = thre'(D_q',D_{fer})$ using D_q' and D_{fer} referred to above. As a method of determining TH_{match}', the same method as the aforementioned handover deleting process may be adopted.

[0077] In Step 1203, the handover base station selector 302 matches handover deleting reference tables U_j and U_m with one another to thereby calculate the maximum matching strength ST_{del}. Fig. 21 shows an embodiment illustrative

of U_j. A reference table storage part 308 stores U_j as the past result of learning. U_j includes a transition $Ul_j = u[L_j(0),L_j(n)]$ of a change in pass loss $L_j(t)$, a transition $Up_j = u[P_j(0),P_j(n)]$ of a change in transmitter power level $P_j(t)$, and handover deletion-destined base stations at that time. U_j is stored in the reference table storage part 308.

[0078] After the calculation of ST_{del} in Step 1203, the handover base station selector 302 proceeds to Step 504. The subsequent processes are similar to the best mode.

3. Third embodiment:

[0079] In the third embodiment, FER of an uplink traffic channel measured by each base station is used in place of the SIR and transmitter power level.

[0080] Figs. 14 and 15 respectively show an embodiment using a transition $Uf_m = u[Fer_m(t-n),Fer_m(t)]$ of a change in FER of uplink traffic channel measured by each connected base station in place of the transition Up_m of change in transmitter power level. Fig. 18 shows an example illustrative of $U_m = [Ul_m,Uf_m]$. A pass loss/FER past information storage part 309 stores, as Um, pass losses of pilot channels reported from each individual mobile stations and FER of uplink traffic channels measured by the connected base stations. Fig. 22 shows an example illustrative of $U_i = [Ui_j, Ui_j]$ and $U_j = u[Ul_j,Uf_j]$. A reference table storage part 310 stores $Ul_j = u[L_j(0),L_j(n)]$ and $Uf_j = u[Fer_j(0),Fer_j(n)]$ therein as learned time-sequential data. Deleted base stations are registered in U_j in place of added base stations. A method of calculating a matching strength threshold and a process for selecting addition/deletion candidates to handover are similar to the example shown in Fig. 10 or 11.

4. Fourth embodiment:

[0081] Each of the methods of performing the handover adding/deleting operations, which are shown in Figs. 8 and 9, corresponds to a method of changing a handover executing method, based on the registered number of reference tables. However, when base stations are increased or taken out after learning data is stored to some extent after system boot-up, it is necessary to re-create the learning data from the beginning. On the other hand, since each of methods shown in Figs. 12 and 13 is a method of changing a handover method, based on a result of comparison between a combination of base stations having received channels intended for the measurement of received levels reported from each mobile station and a combination of base stations written in each reference table, learning data can be updated even if an increase in and removal of base stations being in system operation are performed.

(1) Handover addition at the beginning of system boot-up:

[0082] Fig. 12 shows a handover processing method at the beginning of another system boot-up. According to the present method, combinations of base stations written in a matching-orientated table and a handover adding reference table respectively are retrieved to select an additional candidate.

[0083] In Step 403, a handover base station selector 302 matches handover adding reference tables U_j with a transition U_m of a change in pass loss and SIR reported from each mobile station m to calculate the maximum matching strength ST_{add}. When the maximum matching strength ST_{add} is found to be less than the matching strength threshold TH_{match} in Step 404, the handover base station selector 302 proceeds to Step 1301, where it retrieves a plurality of reference tables U_j as a combination key of connected/non-connected base stations recorded in each matching-orientated table U_m. In Step 1302, the handover base station selector 302 makes a decision as to whether U_j having combinations of base stations coincident with U_m exist. If not so, it means that the learning of handover is insufficient and reference tables are low in number. Therefore, the handover base station selector 302 proceeds to Step 1303 to perform a normal handover. The normal handover is a method of performing it using additional thresholds TH_{add} held by each base station as defaults in place of the additional thresholds obtained from the previously-described result of learning. In Step 1303, the handover base station selector 302 initializes a variable i for retrieving $L_m(t)$ according to base stations. Namely, ones suitable for addition to handover are extracted from a plurality of base stations. In Step 1304, the handover base station selector 302 examines whether values $L_{m,i}(t)$ reported according to base stations of $L_m(t)$ exceed the handover additional threshold TH_{add}. When $L_{m,i}(t)$ greater than TH_{add} is obtained in Step 1304, the handover base station selector 302 selects a base station BTS_i of $L_{m,i}(t)$ as a handover additional candidate base station and proceeds to Step 406. Incidentally, when $L_{m,i}(t)$ greater than TH_{add} is not obtained, the handover base station selector 302 increments i in Step 1306 and compares i and the number of reports in Step 1307. Here, the number of the reports means the total number of base stations existent in adjoining places. If i is greater than or equal to the number of the reports, then the handover base station selector 302 determines that there are no suitable additional candidates and terminates the handover adding process. If i is less than the number of the reports, then the handover base station selector 302 proceeds to Step 1304, where it examines another i+1th base station.

(2) Handover deleting process at the beginning of system boot-up:

[0084] Fig. 13 shows another example of the selecting process at the beginning of the system boot-up shown in Fig. 9. In the present method, combinations of base stations written in a matching-orientated table U_m and a handover deleting reference table U_j respectively are retrieved to select a deletion candidate.

[0085] In Step 503, the handover base station selector 302 matches the reference table U_j and matching-orientated table U_m with each other to thereby calculate the maximum matching strength ST_{del}. When the maximum matching strength ST_{del} is found to be less than the matching strength threshold TH_{match}' in Step 504, the handover base station selector 302 compares combinations of connected/non-connected base stations written in U_m and the handover deleting reference table U_j in Step 1401.

[0086] When the handover base station selector 302 determines in Step 1402 that there are no handover deleting reference tables U_j having combinations of base stations coincident with U_m, it proceeds to Step 1403. This is because since it is considered that the sufficient learning of handover deleting operation is not performed and the handover deleting reference tables are low in number, a normal handover deleting process may preferably be done. The normal handover is a method of performing it using deletion thresholds TH_{del} held by each base station as defaults in place of the deletion thresholds obtained from the previously-described result of learning.

[0087] In Step 1403, the handover base station selector 302 initializes a variable j for retrieving $L_m(i)$ according to base stations. Thereafter, the handover base station selector 302 examines in Step 1404 whether $L_{m,j}(i)$ indicative of values reported according to base stations is less than the normal handover deletion threshold TH_{del}.

[0088] When $L_{m,j}(i)$ less than TH_{del} is obtained in Step 1404, the handover base station selector 302 selects a base station BTS_j of $L_{m,j}(i)$ as a handover deletion candidate base station in Step 1405 and proceeds to Step 506. Incidentally, when $L_{m,j}(i)$ less than TH_{del} is not obtained, the handover base station selector 302 increments j in Step 1406 and compares j and the number of reports in Step 1407. Here, the number of the reports means the total number of base stations existent in adjoining places. If j is greater than or equal to the number of the reports, then the handover base station selector 302 determines that there are no suitable deletion candidates and terminates the handover deleting process. If j is less than the number of the reports, then the handover base station selector 302 proceeds to Step 1404, where it examines another j+1th base station.

5. Other embodiments:

[0089] In the above-described embodiments, the handover between a cell and cell, which forms one service area per base station, has been used. However, as shown in Fig. 23, handover adding/deleting operations can be carried out by the same procedure as the aforementioned cell-to-cell handover even in the case of handover between a sector and a sector by registering even sector numbers in reports on pass losses/SIR or the like from reference tables or mobile stations.

[0090] Further, the aforementioned base station controller is capable of performing, according to the modes, the switching between the case in which the above-described handover adding reference tables and handover deleting reference tables are updated using data from all the mobile stations being in communication under the control of the base station controller, and the updated reference tables are used for handover operations of all the mobile stations, and the case in which reference tables are created every mobile stations and updated using data about pass losses and SIR related to only users for the mobile stations, and the updated reference tables are used only for handover operations of the users for the mobile stations. Namely, a shared table and tables inherent in mobile stations are suitably switched to a plurality of mobile stations. While the above-described embodiments respectively show the method of optimizing the handover operation within the base station controller, switchers may be provided with the same function. Base stations can be also provided with the above-described method of optimizing the handover operation, by causing mobile stations to have the function of inquiring of the base station controller information about the respective base stations.

[0091] While the present invention has been described with reference to the illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to those skilled in the art on reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.

Claims

1. A mobile communication system comprising:

a collection circuit which collects the quality of signals transferred between a mobile station and respective base stations;
a learning circuit which learns data for judging handover, based on the signal quality collected by said collection circuit;
a determination circuit which determins the matching between said data learned by said learning circuit and the quality of signals between the present mobile station and respective base stations, said signal quality being collected by said collection circuit, and
a handover control circuit which controlls handover between said mobile station and each base station corresponding to a handover additional or deletion candidate of said mobile station, based on the result of determination by said determination circuit.

2. A mobile communication system according to claim 1, wherein said learning circuit includes,

a signal quality data storage circuit which stores signal quality of respective base station, which are measured by a mobile station, as time-sequential data therein, and
a handover-destined base station storage circuit which stores handover-destined base stations corresponding to the time-sequential data indicative of the signal quality,
said determination circuit includes,
a handover-destined base station extraction circuit which compares a transition of the present signal quality and time-sequential data about the past signal quality stored in said signal quality data storage circuit, specifies a transition of similar past signal quality, and extracts a handover-destined base station corresponding to the specified transition of past signal quality from said handover-destined base station storage circuit, and
said control circuit includes,
a handover control circuit which controlls handover between the handover-destined base station extracted by said handover-destined extraction circuit and said mobile station.

3. A mobile communication system according to claim 2, further including,

a handover factor storage circuit which stores handover factors therein each of which corresponds to a scale used upon selecting each handover-destined base station stored in said handover-destined base station storage circuit as a handover destination and is determined according to a relation to the transition of signal quality stored in said signal quality data storage circuit.

4. A mobile communication system according to claim 3, wherein when a handover-destined base station has failed in handover still even when the number of times that handover is retried exceeds a predetermined number of retries, said handover control circuit updates the time-sequential data stored in said signal quality data storage circuit so that the corresponding handover-destined base station having failed in handover becomes hard to be selected as the handover-destined base station upon the following handover.

5. A mobile communication system according to claim 4, wherein said handover control circuit includes,

a counter which counts the number of times that the handover is retried, after the commencement of the handover, and
a number-of-retries comparator which compares the value of said counter and a threshold, and

wherein when the value of said counter exceeds the threshold, said handover control circuit updates the time-sequential data stored in said signal quality data storage circuit so that said handover-destined base station becomes hard to be selected as a handover-destined base station upon the following handover.

6. A mobile communication system according to claim 3, wherein said handover control circuit updates the time-sequential data stored in said signal quality data storage circuit so that a handover-destined base station from which handover is deleted immediately after a success in handover, becomes hard to be selected as a handover-destined base station upon the following Handover.

7. A mobile communication system according to claim 6, wherein said handover control circuit includes,

a timer which measures a time interval required to delete a handover-destined base station having succeeded in handover from a handover destination, and
a timer value comparator which compares the value of said timer and a threshold, and

wherein when the value of said counter is less than or equal to the threshold, said handover control circuit updates the time-sequential data stored in said signal quality data storage circuit so that the handover-destined base station becomes hard to be selected as a handover-destined base station upon the following handover.

8. A mobile communication system comprising:

a first storage circuit which stores therein time-sequential data about base station reception quality measured by a mobile station;
a second storage circuit which stores therein time-sequential data about past base station reception quality and handover additional candidates corresponding to the time-sequential data;
a third storage circuit which stores therein time-sequential data about reception quality of a mobile station therein, said reception quality being measured by a base station connected to the mobile station, of said base stations;
a determination circuit which determines a handover threshold from the time-sequential data about the base station reception quality, which are stored in said first storage circuit and the time-sequential data about the reception quality of the mobile station, said time-sequential data being stored in said third storage circuit;
a calculation circuit which matches the time-sequential data about the base station reception quality, which are stored in said first storage circuit and the time-sequential data about the past base station reception quality, which are stored in said second storage circuit and calculating the degree of said matching; and
a selection circuit which compares said handover threshold and said degree of matching and selecting a base station brought to a handover additional candidate, based on the comparison thereof.

9. A mobile communication system according to claim 8, further including a power control circuit which determines a power control condition used upon handover addition, based on reception quality of the handover addition base station selected by said selection circuit and reception quality of a base station being in connection with said mobile station.

10. A mobile communication system according to claim 8, further including a deletion grace condition determination circuit which determines a condition for allowing of the deletion of each base station added to handover from the handover, based on the reception quality of the handover addition base station selected by said selection circuit and the reception quality of the base station being in connection with said mobile station.

11. A mobile communication system according to claim 8, further including a number-of-retries determination circuit which determines the additional number of retries executed upon handover addition, based on the reception quality of the handover addition base station selected by said selection circuit and the reception quality of the base station being in connection with said mobile station.

12. A mobile communication system according to claim 11, further including,

a counter which counts the number of times that handover for the handover addition base station selected by said selection circuit and said mobile station is retried;
a number-of-retries comparator which compares the number of retries measured by said counter and the additional number of retries determined by said number-of-retries determination circuit; and
a learning circuit which allows the handover addition base station to learn so that the handover addition base station is hard to be added to handover as to the reception quality at the selection of the handover addition base station when the number of retries is over the additional number of retries.

13. A mobile communication system according to claim 11, further including,

a counter which counts the number of times that handover for the handover addition base station selected by said selection circuit and said mobile station is retried;
a number-of-retries comparator which compares the number of retries measured by said counter and the additional number of retries determined by said number-of-retries determination circuit; and
a learning circuit which allows the handover addition base station to learn so that the handover addition base station is further easy to be added to handover when the number of retries is under the additional number of retries.

14. A mobile communication system according to claim 8, further including,

a timer which measures a time interval required to delete the handover addition base station selected by said selection circuit again after the handover addition base station and the mobile station have succeeded in handover; and

a learning circuit which allows the handover addition base station to learn so that the handover addition base station is hard to be added to handover next time when the time interval measured by said timer is under a threshold.

15. A mobile communication system according to claim 1, wherein said learning circuit includes,

a signal quality data storage circuit which stores signal quality of respective base stations, which are measured by a mobile station, as time-sequential data therein, and

a handover deletion base station storage circuit which stores handover deletion base stations corresponding to the time-sequential data about the signal quality,

said determination circuit includes,

a handover deletion base station extraction circuit which compares a transition of the present signal quality and time-sequential data about the past signal quality stored in said signal quality data storage circuit, specifies a transition of similar past signal quality, and extracts a handover deletion base station corresponding to the specified transition of past signal quality from said handover deletion base station storage circuit, and

said control circuit includes,

a handover control circuit which controls handover between the base station extracted by said handover deletion base station extraction circuit and said mobile station.

16. A mobile communication system according to claim 15, further including,

a timer which measures a time interval required to add the handover deletion base station to handover again after the deletion of the handover deletion base station, and

a learning circuit which allows the handover deletion base station to learn so that the handover deletion base station is hard to be deleted from handover next time when the time interval measured by said timer is under a threshold.

17. A mobile communication system according to claim 15, further including,

an addition condition determination circuit which determines an additional condition for allowing of the addition of each base station deleted from handover to the handover again, based on the reception quality of the handover deletion base station selected by said selection circuit and the reception quality of the base station being in connection with said mobile station, and

wherein said handover control circuit refuses addition to handover when said additional condition is not met even if the base station deleted from the handover becomes a candidate added to the handover again.

18. A mobile communication system according to claim 1, wherein when the handover judging data held in said learning circuit lacks, said determination circuit determines matching between the signal quality between the present mobile station and the respective base stations, said signal quality being collected by said collection circuit and thresholds of defaults.

FIG.1

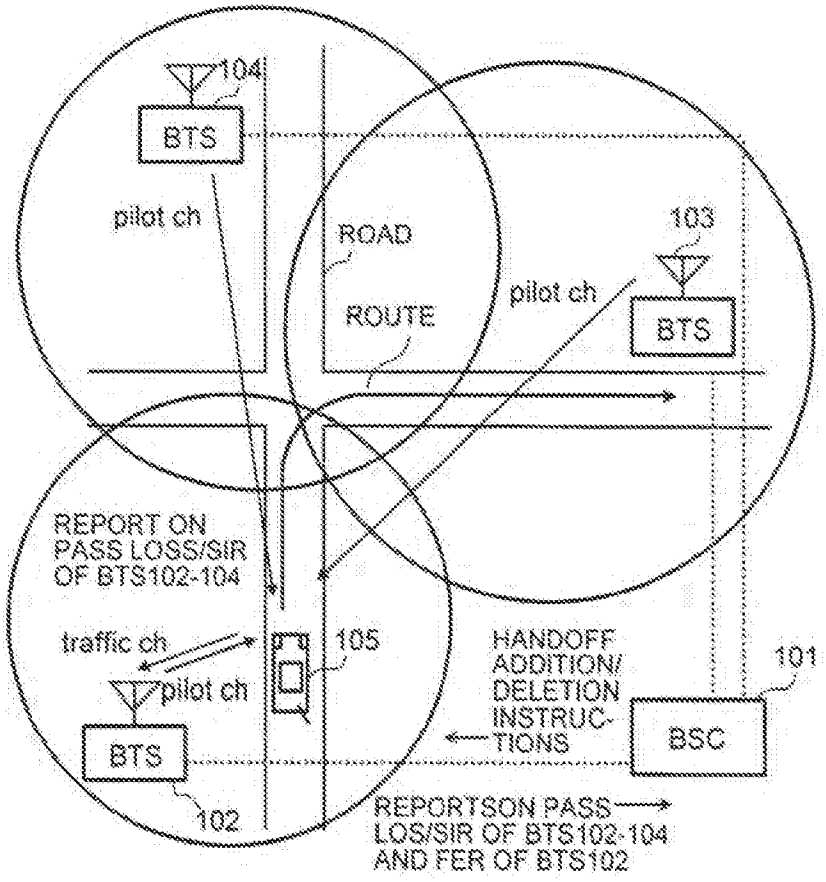

104
BTS
pilot ch
ROAD
ROUTE
103
pilot ch
BTS
REPORT ON
PASS LOSS/SIR
OF BTS102-104
traffic ch
pilot ch
105
BTS
102
HANDOFF
ADDITION/
DELETION
INSTRUC-
TIONS
101
BSC
REPORTSON PASS
LOS/SIR OF BTS102-104
AND FER OF BTS102

FIG.2

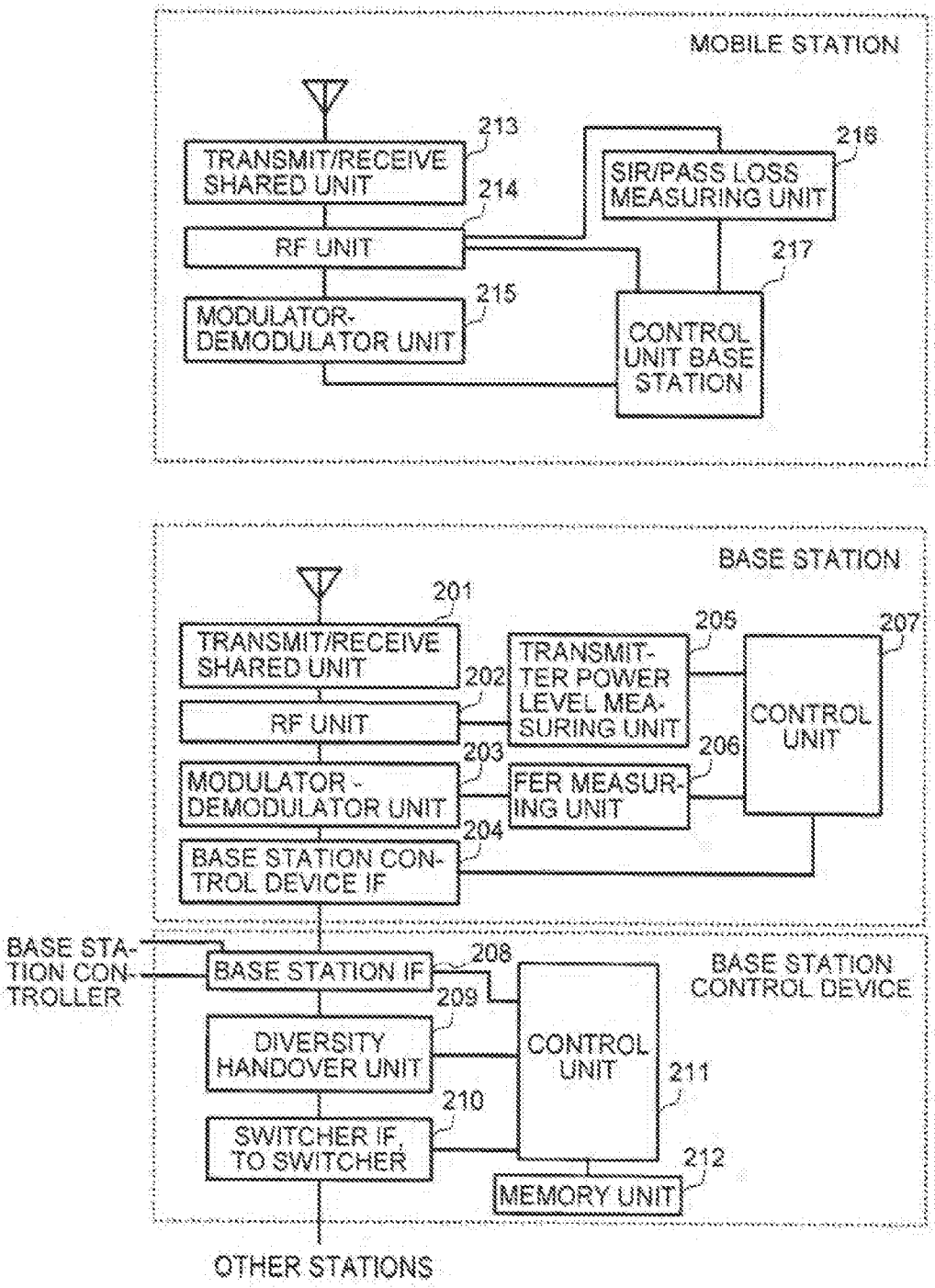

MOBILE STATION
TRANSMIT/RECEIVE SHARED UNIT
213
214
RF UNIT
MODULATOR-DEMODULATOR UNIT
215
SIR/PASS LOSS MEASURING UNIT
216
217
CONTROL UNIT BASE STATION
BASE STATION
201
TRANSMIT/RECEIVE SHARED UNIT
202
RF UNIT
203
MODULATOR - DEMODULATOR UNIT
204
BASE STATION CONTROL DEVICE IF
205
TRANSMITTER POWER LEVEL MEASURING UNIT
206
FER MEASURING UNIT
207
CONTROL UNIT
BASE STATION CONTROLLER
208
BASE STATION IF
209
DIVERSITY HANDOVER UNIT
210
SWITCHER IF, TO SWITCHER
CONTROL UNIT
211
MEMORY UNIT
212
BASE STATION CONTROL DEVICE
OTHER STATIONS

FIG.3A

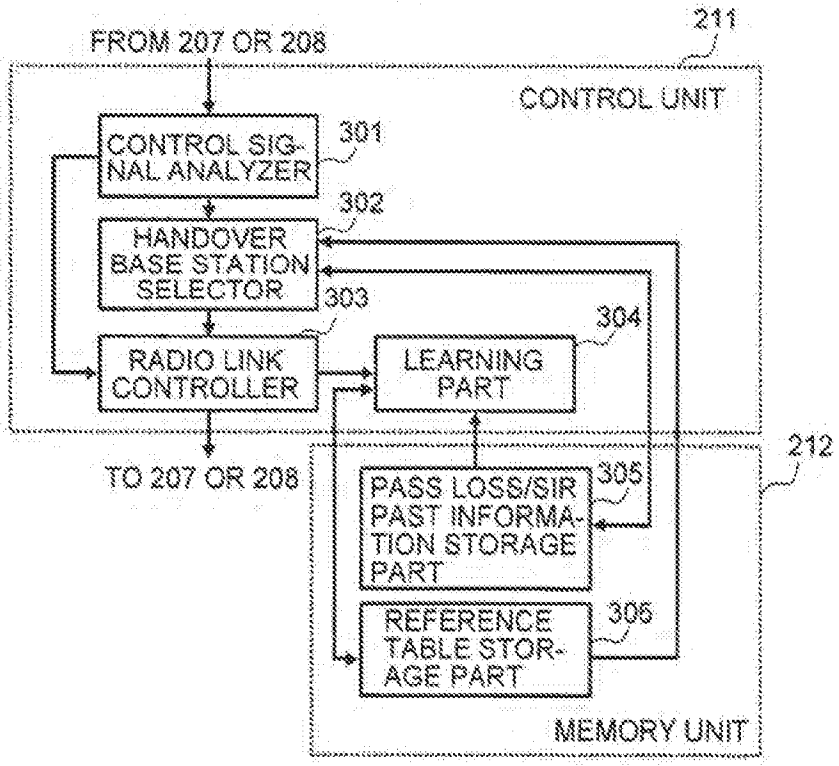


FIG.3B

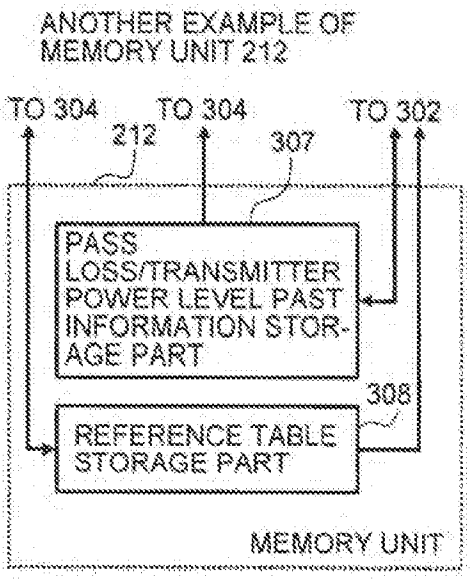


FIG.3C

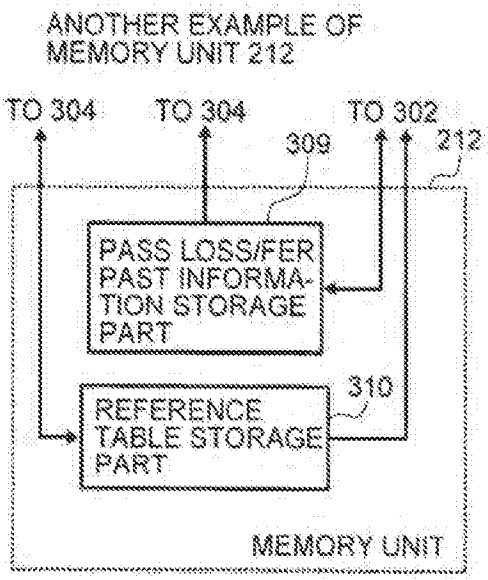


FIG.4

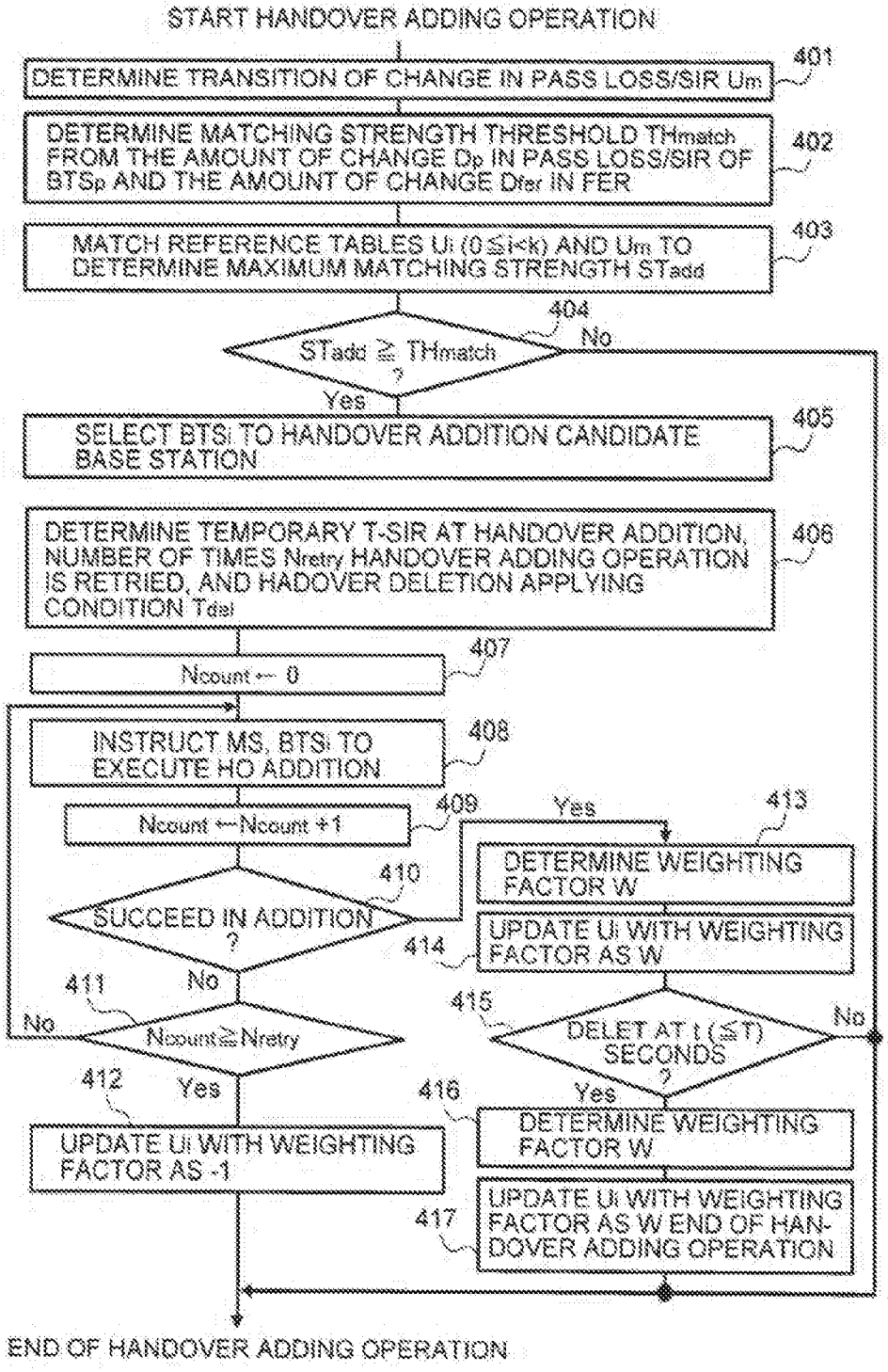

START HANDOVER ADDING OPERATION
DETERMINE TRANSITION OF CHANGE IN PASS LOSS/SIR Um
401
DETERMINE MATCHING STRENGTH THRESHOLD THmatch FROM THE AMOUNT OF CHANGE Dp IN PASS LOSS/SIR OF BTSp AND THE AMOUNT OF CHANGE Dfer IN FER
402
MATCH REFERENCE TABLES Ui (0≦i<k) AND Um TO DETERMINE MAXIMUM MATCHING STRENGTH STadd
403
STadd ≧ THmatch ?
404
No
Yes
SELECT BTSi TO HANDOVER ADDITION CANDIDATE BASE STATION
405
DETERMINE TEMPORARY T-SIR AT HANDOVER ADDITION, NUMBER OF TIMES Nretry HANDOVER ADDING OPERATION IS RETRIED, AND HADOVER DELETION APPLYING CONDITION Tdel
406
Ncount ← 0
407
INSTRUCT MS, BTSi TO EXECUTE HO ADDITION
408
Ncount ← Ncount +1
409
Yes
413
DETERMINE WEIGHTING FACTOR W
SUCCEED IN ADDITION ?
410
UPDATE Ui WITH WEIGHTING FACTOR AS W
414
No
411
No
Ncount≧Nretry
415
DELET AT t (≦T) SECONDS ?
No
412
Yes
Yes
416
DETERMINE WEIGHTING FACTOR W
UPDATE Ui WITH WEIGHTING FACTOR AS -1
UPDATE Ui WITH WEIGHTING FACTOR AS W END OF HANDOVER ADDING OPERATION
417
END OF HANDOVER ADDING OPERATION

FIG.5

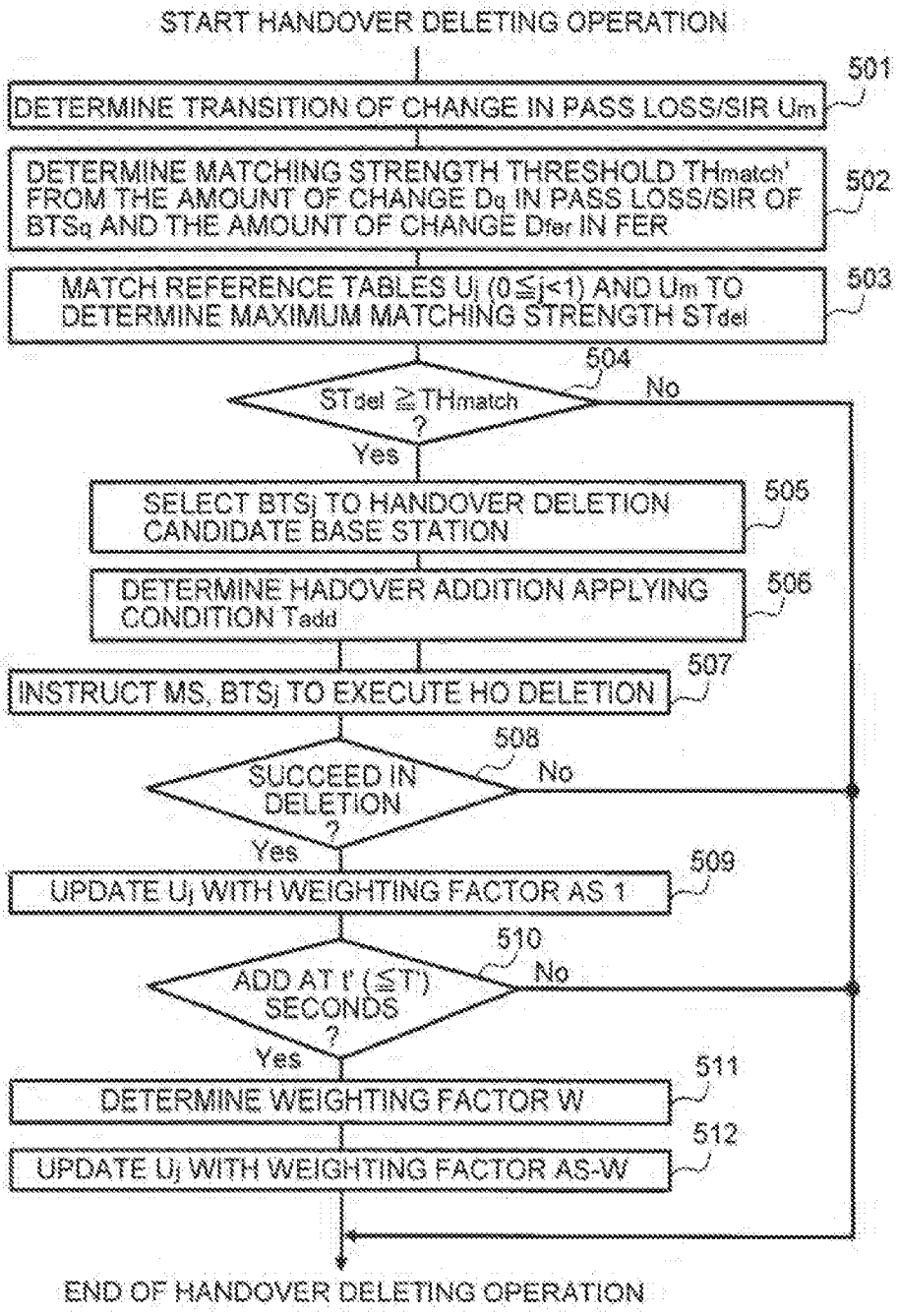

START HANDOVER DELETING OPERATION
DETERMINE TRANSITION OF CHANGE IN PASS LOSS/SIR Um
501
DETERMINE MATCHING STRENGTH THRESHOLD THmatch' FROM THE AMOUNT OF CHANGE Dq IN PASS LOSS/SIR OF BTSq AND THE AMOUNT OF CHANGE Dfer IN FER
502
MATCH REFERENCE TABLES Uj (0≦j<1) AND Um TO DETERMINE MAXIMUM MATCHING STRENGTH STdel
503
STdel ≧ THmatch ?
504
No
Yes
SELECT BTSj TO HANDOVER DELETION CANDIDATE BASE STATION
505
DETERMINE HADOVER ADDITION APPLYING CONDITION Tadd
506
INSTRUCT MS, BTSj TO EXECUTE HO DELETION
507
SUCCEED IN DELETION ?
508
No
Yes
UPDATE Uj WITH WEIGHTING FACTOR AS 1
509
ADD AT t' (≦T') SECONDS ?
510
No
Yes
DETERMINE WEIGHTING FACTOR W
511
UPDATE Uj WITH WEIGHTING FACTOR AS-W
512
END OF HANDOVER DELETING OPERATION

FIG.6

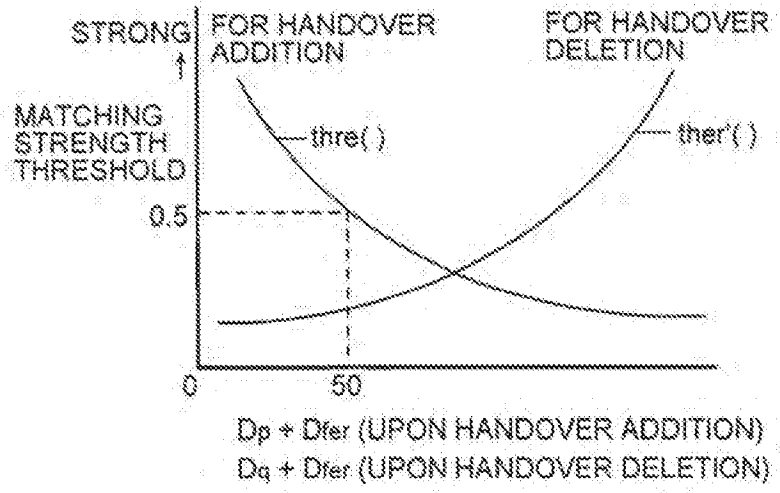

STRONG
FOR HANDOVER ADDITION
FOR HANDOVER DELETION
MATCHING STRENGTH THRESHOLD
thre( )
ther'( )
0.5
0
50
Dp + Dfer (UPON HANDOVER ADDITION)
Dq + Dfer (UPON HANDOVER DELETION)

FIG.7

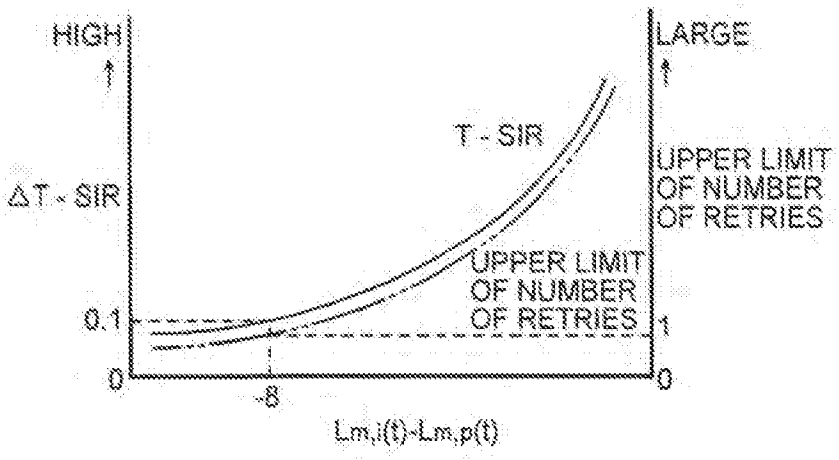

HIGH
LARGE
T - SIR
ΔT - SIR
UPPER LIMIT OF NUMBER OF RETRIES
UPPER LIMIT OF NUMBER OF RETRIES
0.1
1
0
0
-8
Lm,i(t)-Lm,p(t)

FIG.8

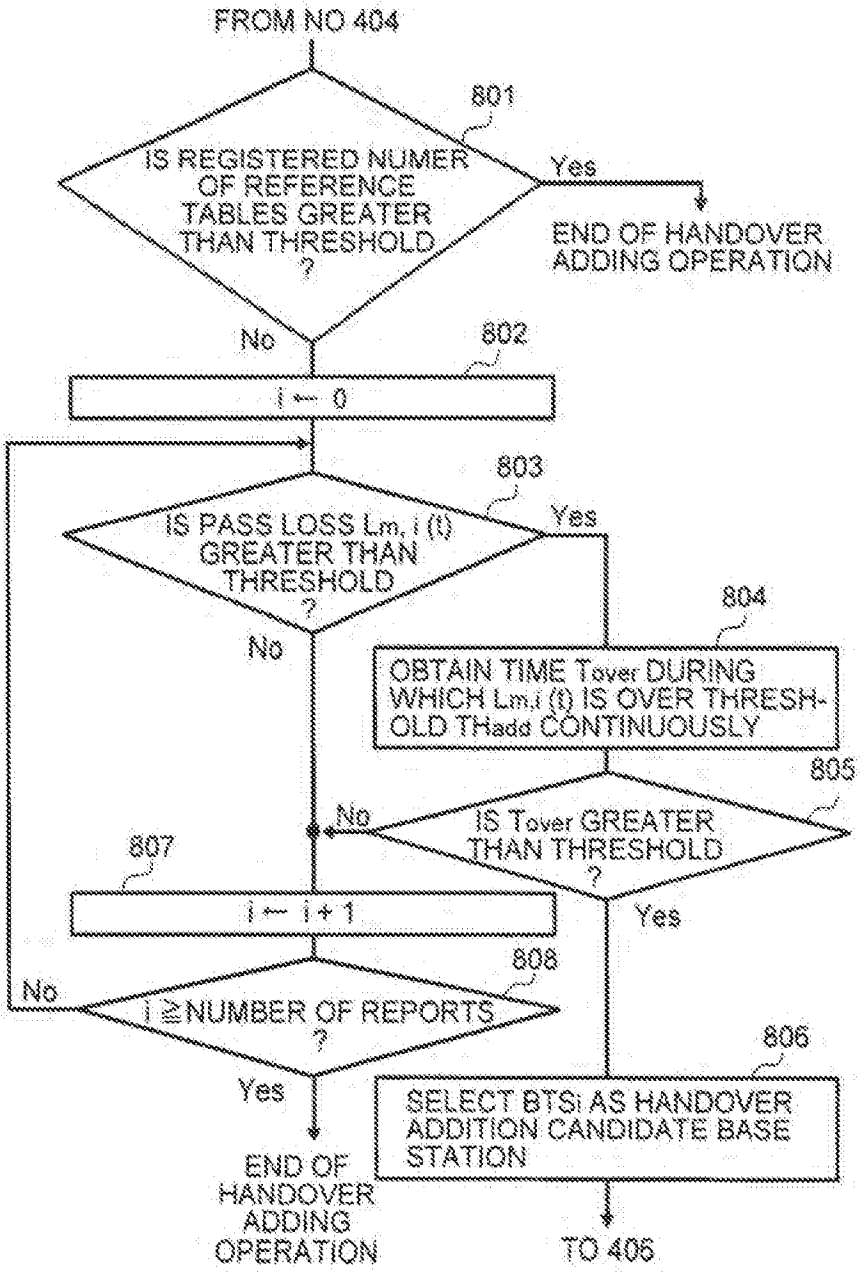

FROM NO 404
801
IS REGISTERED NUMER OF REFERENCE TABLES GREATER THAN THRESHOLD ?
Yes
END OF HANDOVER ADDING OPERATION
No
802
i ← 0
803
IS PASS LOSS Lm, i (t) GREATER THAN THRESHOLD ?
Yes
No
804
OBTAIN TIME Tover DURING WHICH Lm,i (t) IS OVER THRESHOLD THadd CONTINUOUSLY
805
IS Tover GREATER THAN THRESHOLD ?
No
Yes
807
i ← i + 1
808
i ≧ NUMBER OF REPORTS ?
No
Yes
806
SELECT BTSi AS HANDOVER ADDITION CANDIDATE BASE STATION
END OF HANDOVER ADDING OPERATION
TO 405

FIG.9

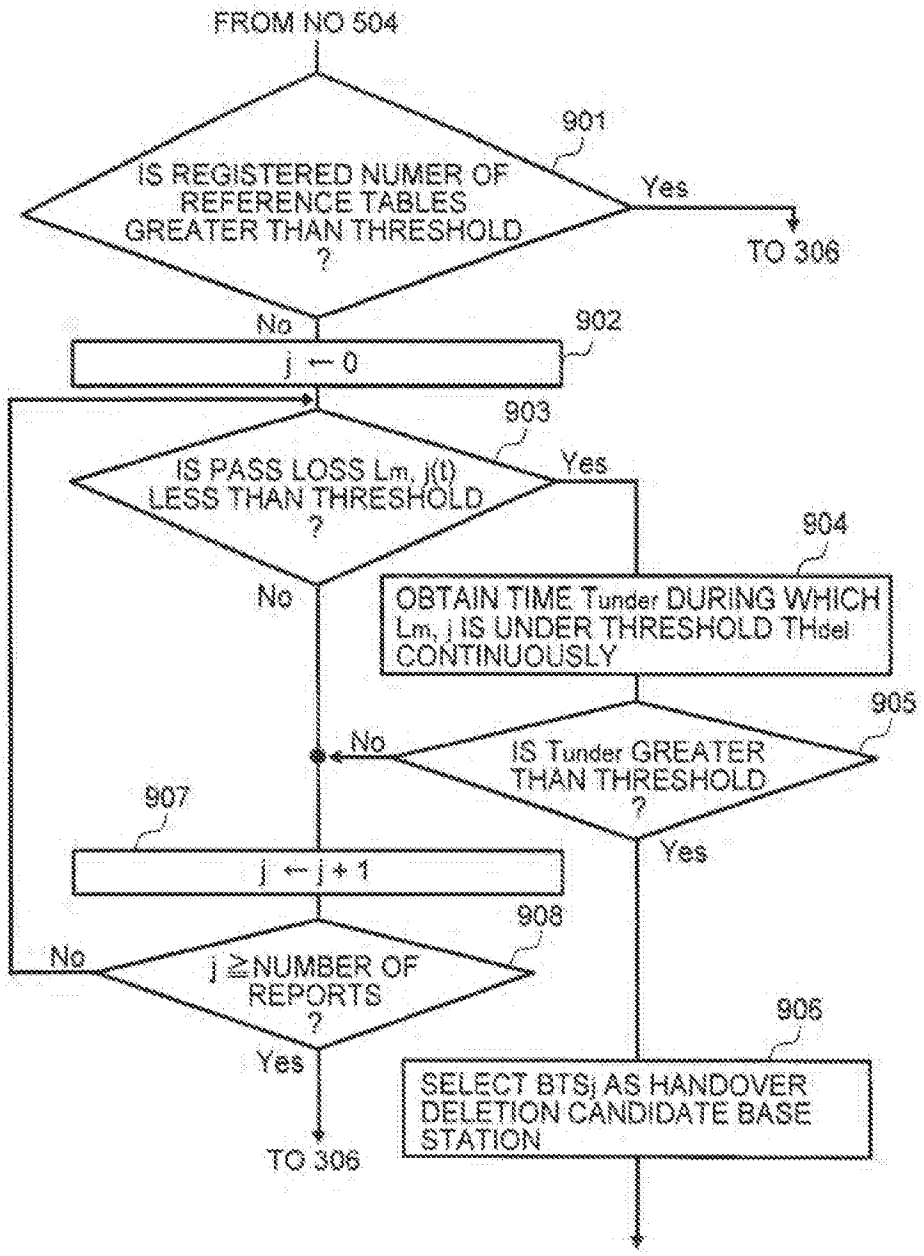

FROM NO 504
901
IS REGISTERED NUMER OF REFERENCE TABLES GREATER THAN THRESHOLD ?
Yes
TO 306
No
902
j ← 0
903
IS PASS LOSS Lm, j(t) LESS THAN THRESHOLD ?
Yes
No
904
OBTAIN TIME Tunder DURING WHICH Lm, j IS UNDER THRESHOLD THsel CONTINUOUSLY
905
IS Tunder GREATER THAN THRESHOLD ?
No
Yes
907
j ← j + 1
908
j ≧NUMBER OF REPORTS ?
No
Yes
TO 306
906
SELECT BTSj AS HANDOVER DELETION CANDIDATE BASE STATION

FIG.10

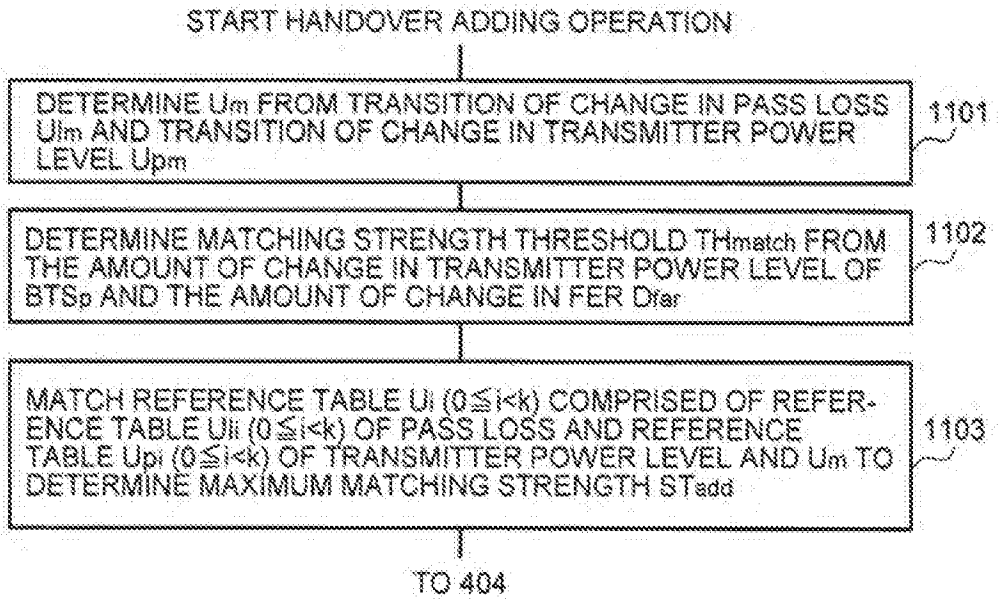

START HANDOVER ADDING OPERATION
DETERMINE Um FROM TRANSITION OF CHANGE IN PASS LOSS Ulm AND TRANSITION OF CHANGE IN TRANSMITTER POWER LEVEL Upm
1101
DETERMINE MATCHING STRENGTH THRESHOLD THmatch FROM THE AMOUNT OF CHANGE IN TRANSMITTER POWER LEVEL OF BTSp AND THE AMOUNT OF CHANGE IN FER Dfer
1102
MATCH REFERENCE TABLE Ui (0≦i<k) COMPRISED OF REFERENCE TABLE Uli (0≦i<k) OF PASS LOSS AND REFERENCE TABLE Upi (0≦i<k) OF TRANSMITTER POWER LEVEL AND Um TO DETERMINE MAXIMUM MATCHING STRENGTH STadd
1103
TO 404

FIG.11

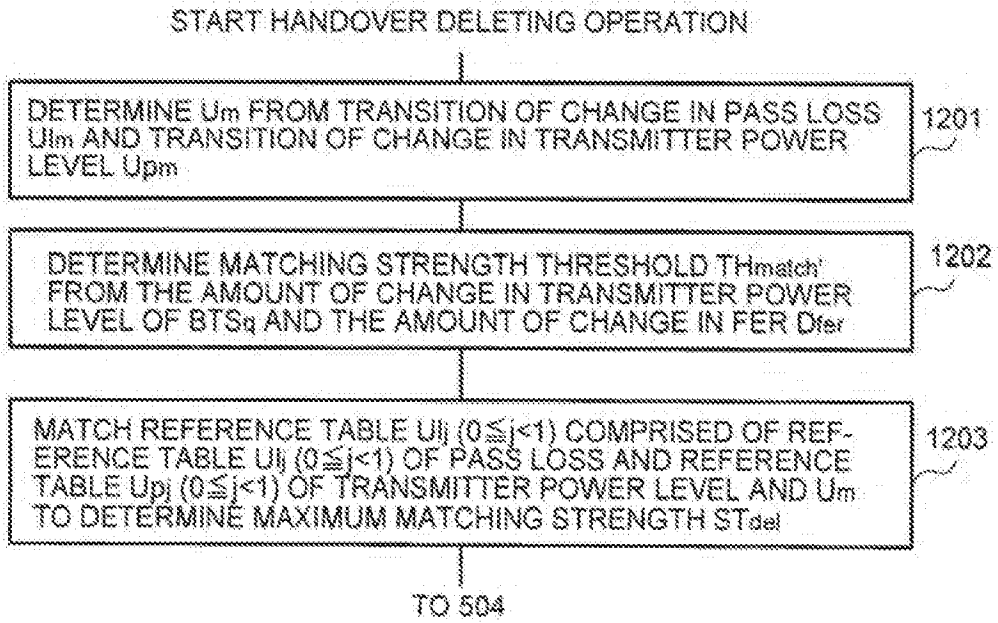

START HANDOVER DELETING OPERATION
DETERMINE Um FROM TRANSITION OF CHANGE IN PASS LOSS Ulm AND TRANSITION OF CHANGE IN TRANSMITTER POWER LEVEL Upm
1201
DETERMINE MATCHING STRENGTH THRESHOLD THmatch' FROM THE AMOUNT OF CHANGE IN TRANSMITTER POWER LEVEL OF BTSq AND THE AMOUNT OF CHANGE IN FER Dfer
1202
MATCH REFERENCE TABLE Uj (0≦j<1) COMPRISED OF REFERENCE TABLE Ulj (0≦j<1) OF PASS LOSS AND REFERENCE TABLE Upj (0≦j<1) OF TRANSMITTER POWER LEVEL AND Um TO DETERMINE MAXIMUM MATCHING STRENGTH STdel
1203
TO 504

FIG.12

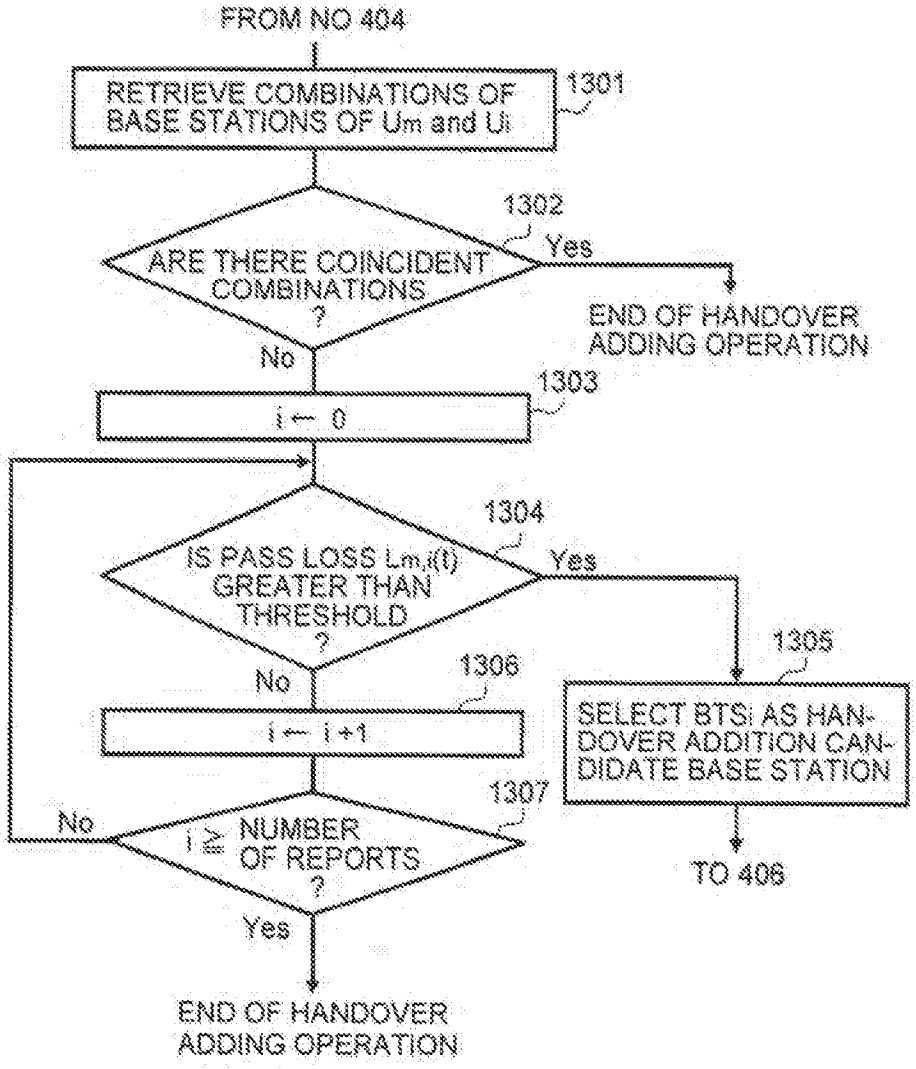

FROM NO 404
RETRIEVE COMBINATIONS OF BASE STATIONS OF Um and Ui
1301
ARE THERE COINCIDENT COMBINATIONS ?
1302
Yes
END OF HANDOVER ADDING OPERATION
No
i ← 0
1303
IS PASS LOSS Lm,i(l) GREATER THAN THRESHOLD ?
1304
Yes
SELECT BTSi AS HANDOVER ADDITION CANDIDATE BASE STATION
1305
No
i ← i +1
1306
i ≧ NUMBER OF REPORTS ?
1307
No
Yes
TO 406
END OF HANDOVER ADDING OPERATION

FIG.13

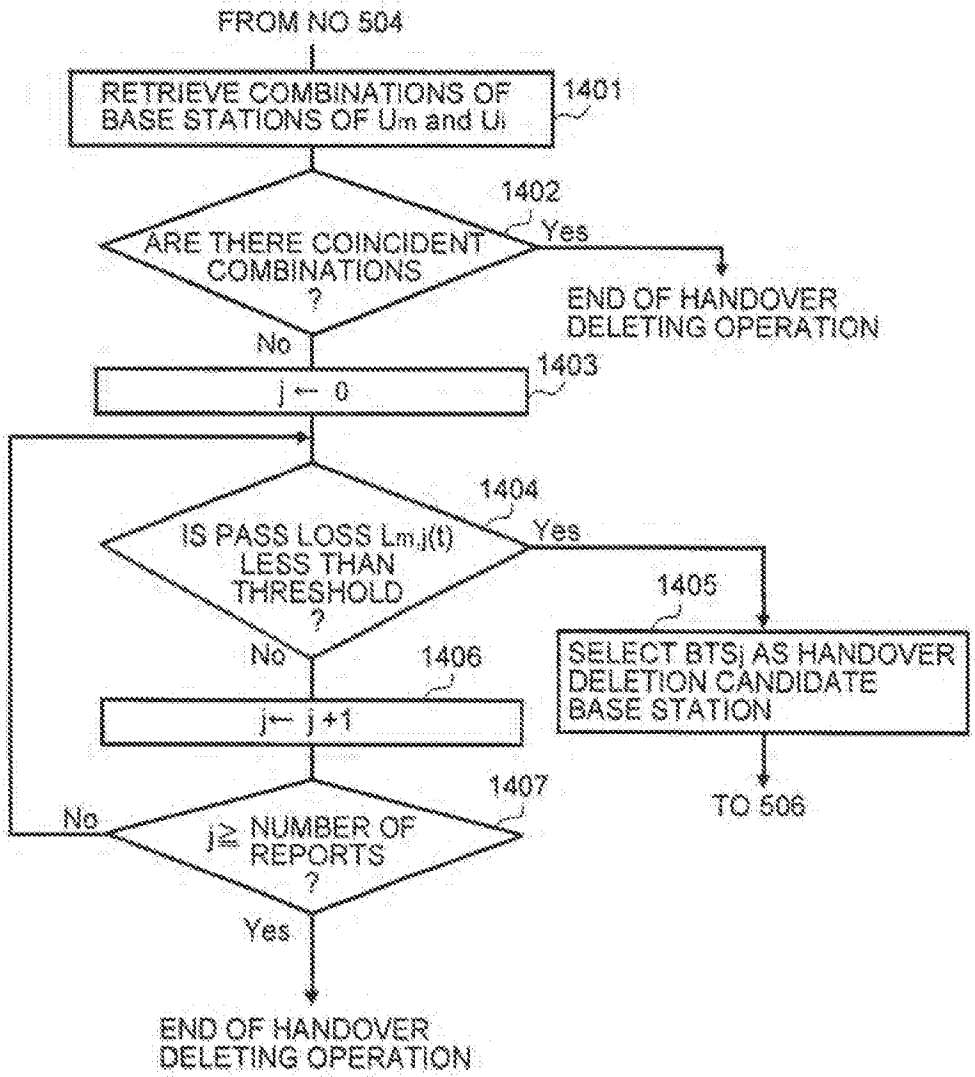

FROM NO 504
RETRIEVE COMBINATIONS OF BASE STATIONS OF Um and Ui
1401
ARE THERE COINCIDENT COMBINATIONS ?
1402
Yes
END OF HANDOVER DELETING OPERATION
No
j ← 0
1403
IS PASS LOSS Lm,j(t) LESS THAN THRESHOLD ?
1404
Yes
1405
SELECT BTSj AS HANDOVER DELETION CANDIDATE BASE STATION
TO 506
No
1406
j ← j +1
j≧ NUMBER OF REPORTS ?
1407
No
Yes
END OF HANDOVER DELETING OPERATION

FIG.14

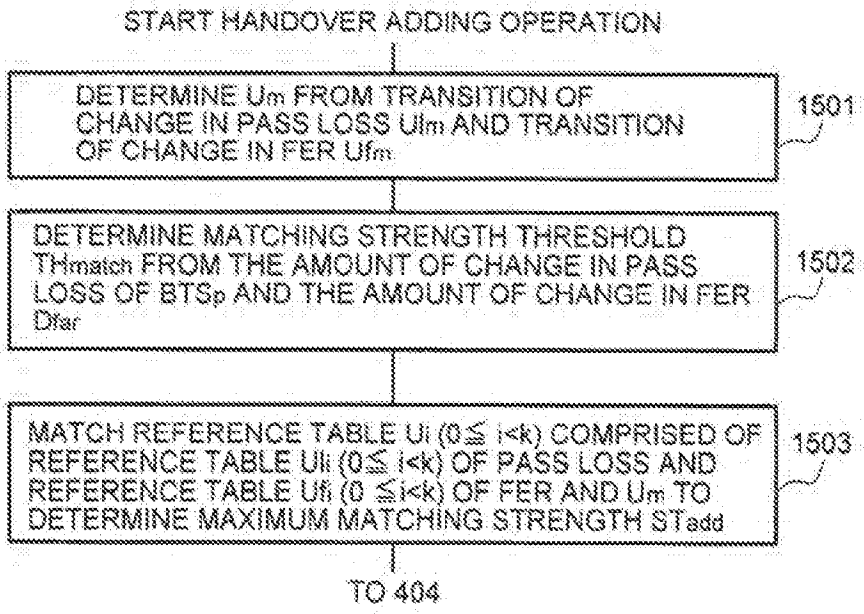

START HANDOVER ADDING OPERATION
DETERMINE Um FROM TRANSITION OF CHANGE IN PASS LOSS Ulm AND TRANSITION OF CHANGE IN FER Ufm
1501
DETERMINE MATCHING STRENGTH THRESHOLD THmatch FROM THE AMOUNT OF CHANGE IN PASS LOSS OF BTSp AND THE AMOUNT OF CHANGE IN FER Dfar
1502
MATCH REFERENCE TABLE Ul (0≦ l<k) COMPRISED OF REFERENCE TABLE Ull (0≦ l<k) OF PASS LOSS AND REFERENCE TABLE Ufl (0 ≦l<k) OF FER AND Um TO DETERMINE MAXIMUM MATCHING STRENGTH STadd
1503
TO 404

FIG.15

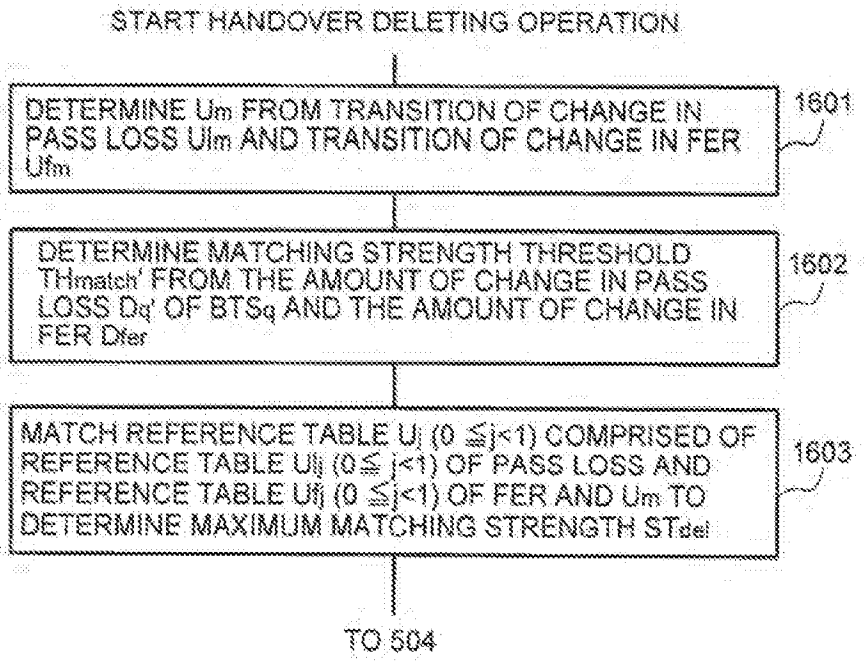

START HANDOVER DELETING OPERATION
DETERMINE Um FROM TRANSITION OF CHANGE IN PASS LOSS Ulm AND TRANSITION OF CHANGE IN FER Ufm
1601
DETERMINE MATCHING STRENGTH THRESHOLD THmatch' FROM THE AMOUNT OF CHANGE IN PASS LOSS Dq' OF BTSq AND THE AMOUNT OF CHANGE IN FER Dfer
1602
MATCH REFERENCE TABLE Uj (0 ≦j<1) COMPRISED OF REFERENCE TABLE Ulj (0≦ j<1) OF PASS LOSS AND REFERENCE TABLE Ufj (0 ≦j<1) OF FER AND Um TO DETERMINE MAXIMUM MATCHING STRENGTH STdel
1603
TO 504

FIG.16

TIME	BTS102		BTS103		BTS104		BTS102
	PASS LOSS	SIR	PASS LOSS	SIR	PASS LOSS	SIR	FER
t-n	2	20	10	6	7	7	0
t-n+1	3	18	8	8	7	6	1
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	10	12	2	15	10	6	30
	CONNECTED		NON-CONNECTED		NON-CONNECTED		

Um

Lm(t)

UNIT EXAMPLE : PASS LOSS ··· dB μ SIR ··· dB

Ferm,p(t) / Ferm,q(t)

FIG.17

TIME	BTS102 PASS LOSS	BTS103 PASS LOSS	FER		TRANSMITTER POWER LEVEL	
			BTS102	BTS103	BTS102	BTS103
t-n	1	3	0	20	10	15
t-n+1	3	5	5	25	14	20
⋮	⋮	⋮	⋮	⋮	⋮	⋮
1	4	8	10	40	15	30
	CONNECTED	CONNECTED				

Lm(t)

Pm(t)

Ulm

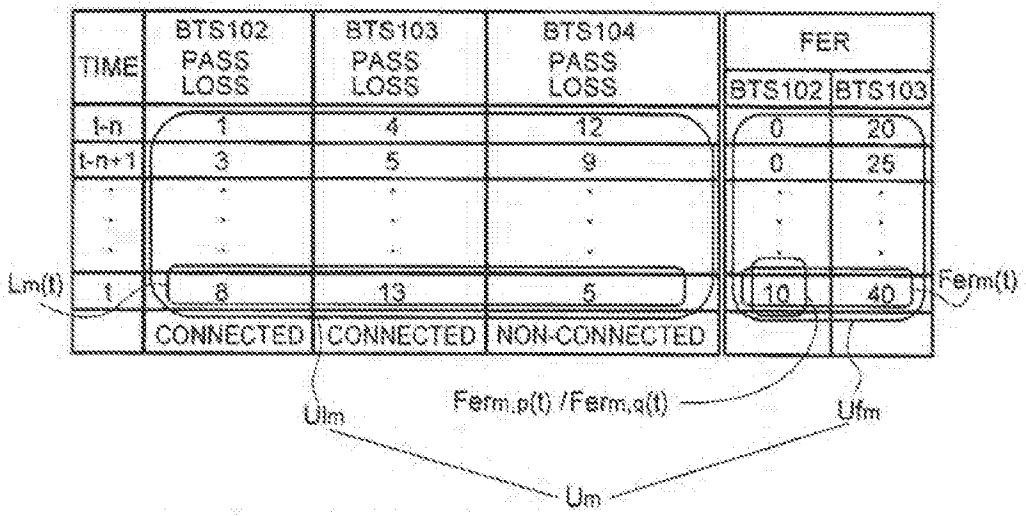
Ferm,p(t) / Ferm,q(t)

Upm

Um

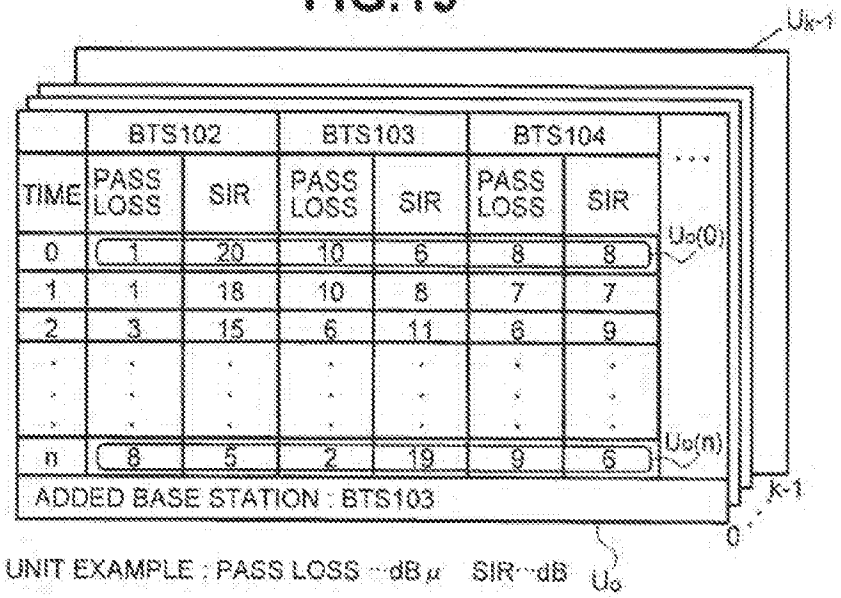
UNIT EXAMPLE : PASS LOSS ···dB μ TRANSMITTER POWER LEVEL ···dB

FIG.18



UNIT EXAMPLE : PASS LOSS ··· dB μ

FIG.19



UNIT EXAMPLE : PASS LOSS ···dB μ SIR···dB

FIG.20

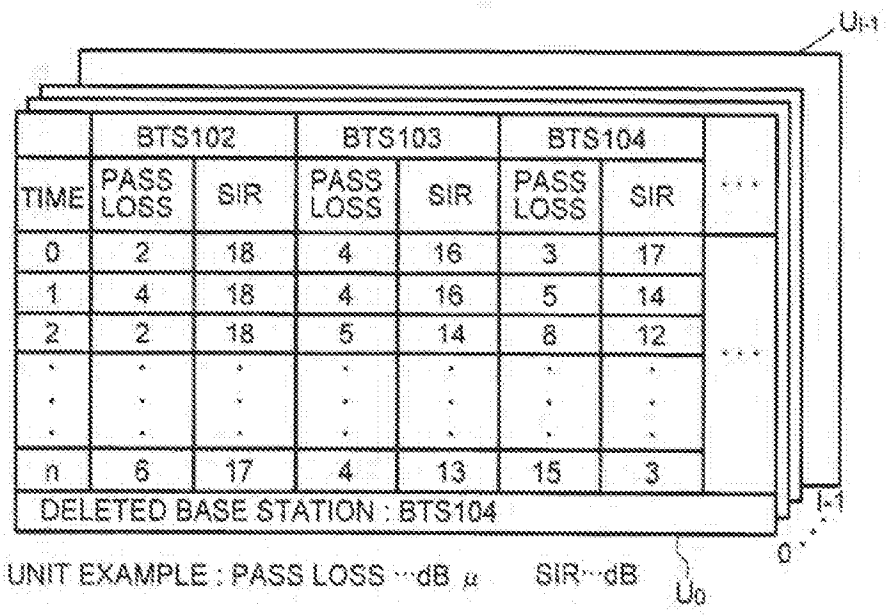

UI-1
BTS102
BTS103
BTS104
TIME
PASS LOSS
SIR
PASS LOSS
SIR
PASS LOSS
SIR
0 2 18 4 16 3 17
1 4 18 4 16 5 14
2 2 18 5 14 8 12
n 6 17 4 13 15 3
DELETED BASE STATION : BTS104
I-1
0
UNIT EXAMPLE : PASS LOSS ···dB μ SIR···dB
U0

FIG.21

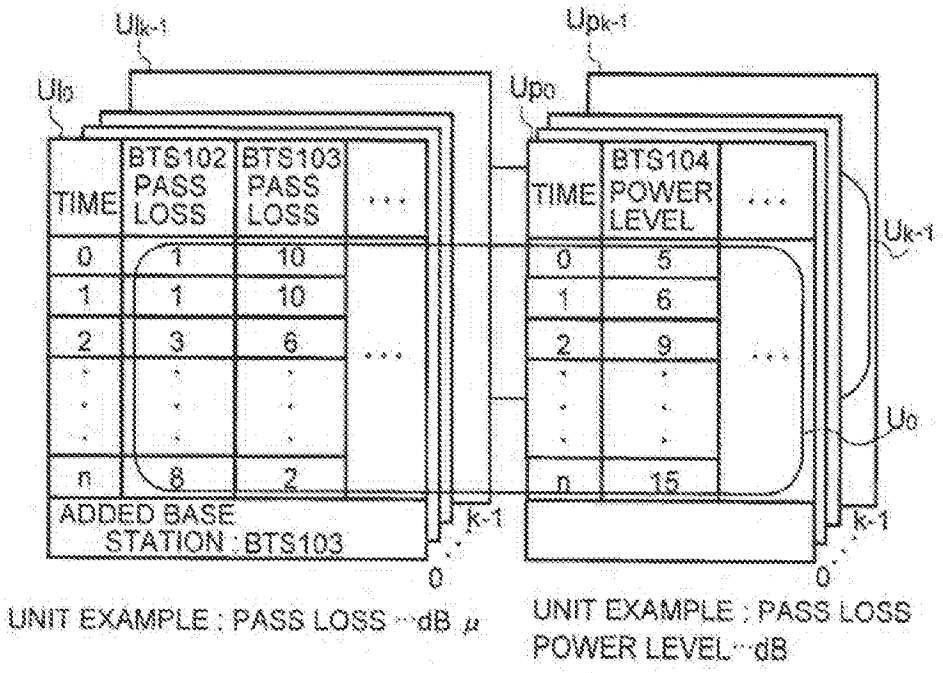
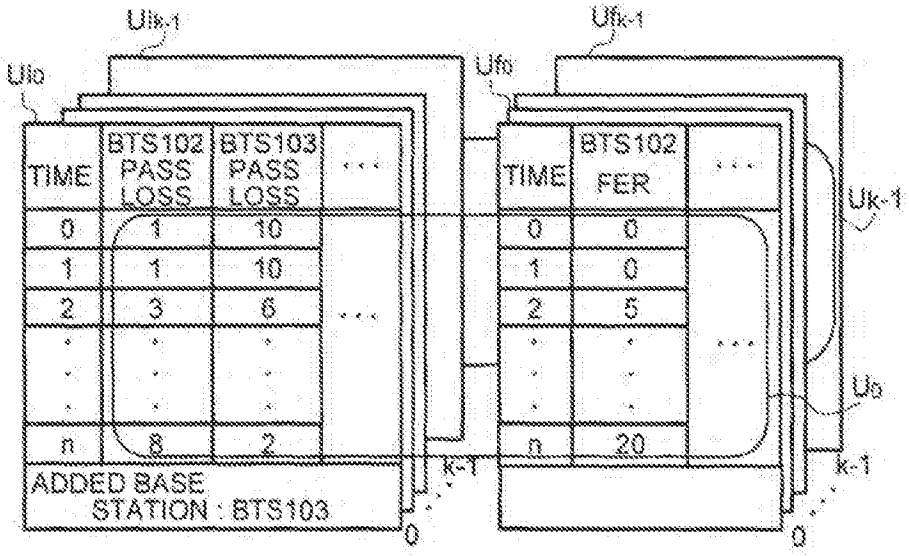
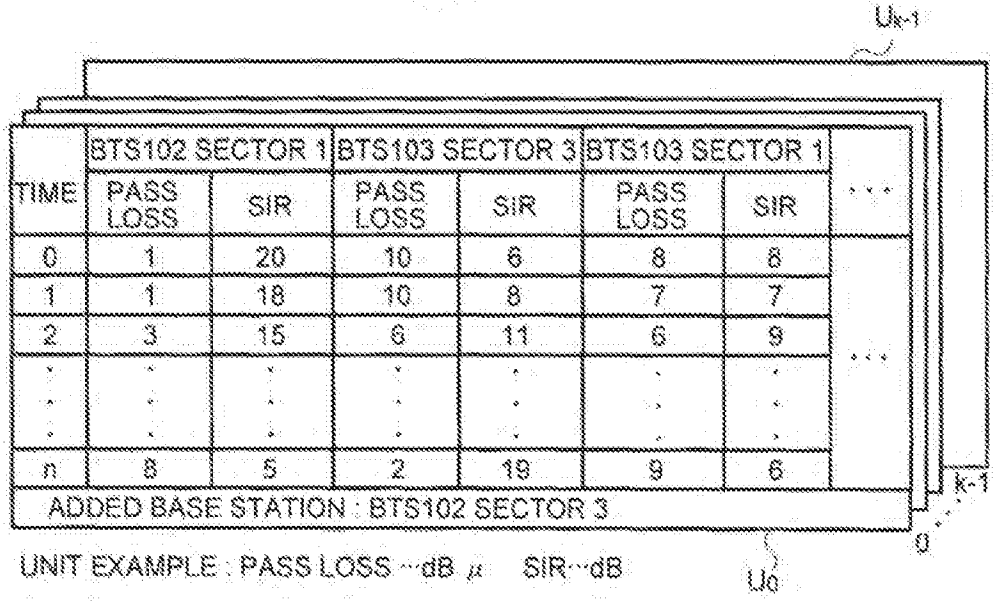

UIk-1
UIo
TIME
BTS102 PASS LOSS
BTS103 PASS LOSS
0 1 10
1 1 10
2 3 6
n 8 2
ADDED BASE STATION : BTS103
k-1
0
UNIT EXAMPLE : PASS LOSS ···dB μ
UPk-1
UPo
TIME
BTS104 POWER LEVEL
0 5
1 6
2 9
n 15
Uk-1
U0
k-1
0
UNIT EXAMPLE : PASS LOSS POWER LEVEL···dB

FIG.22



UNIT EXAMPLE : PASS LOSS ···dB μ

FIG.23



TIME	BTS102 SECTOR 1		BTS103 SECTOR 3		BTS103 SECTOR 1		···
	PASS LOSS	SIR	PASS LOSS	SIR	PASS LOSS	SIR	
0	1	20	10	6	8	8	
1	1	18	10	8	7	7	
2	3	15	6	11	6	9	···
⋮	⋮	⋮	⋮	⋮	⋮	⋮	
n	8	5	2	19	9	6	

UNIT EXAMPLE : PASS LOSS ···dB μ SIR···dB

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 10 2067

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WONG D ET AL: "MULTI-STATE PATTERN RECOGNITION HANDOFF ALGORITHMS" IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE,US,NEW YORK, NY: IEEE, 1998, pages 1420-1425, XP000805147 ISBN: 0-7803-4985-7	1,2,15, 18	H04Q7/38
Y	* page 1421, left-hand column, paragraph 2 - page 1422, right-hand column, paragraph 2; figure 1 * * page 1424, left-hand column, paragraph 3 - page 1425, left-hand column, paragraph 2; figure 5 *	4-7,16, 17	
Y	EP 0 849 967 A (LUCENT TECHNOLOGIES INC) 24 June 1998 (1998-06-24) * column 2, line 31 - column 3, line 3; claims 6-10; figure 4 *	4-7,16, 17	
A	SALMASI A ET AL: "ON THE SYSTEM DESIGN ASPECTS OF CODE DIVISION MULTIPLE ACCESS (CDMA) APPLIED TO DIGITAL CELLULAR AND PERSONAL COMMUNICATIONS NETWORKS" IEEE VEHICULAR TECHNOLOGY CONFERENCE,US,NEW YORK, IEEE, vol. CONF. 41, 19 May 1991 (1991-05-19), pages 57-62, XP000260154 ISBN: 0-87942-562-2 * page 61, left-hand column, paragraph 6 - page 61, right-hand column, paragraph 4 *	15	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	28 February 2001	Kreppel, J

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EUROPEAN SEARCH REPORT

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EP 00 10 2067

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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A	NARASIMHAN R; COX D C: "A handoff algorithm for wireless systems using pattern recognition" NINTH IEEE INTERNATIONAL SYMPSIUM ON PERSONAL, INDOOR AND MOBILE RADIO COMMUNICATION, PROCEEDINGS OF NINTH INTERNATIONAL SYMPOSIUM ON PERSONAL, INDOOR AND MOBILE RADIO COMMUNICATIONS (PIMRC'98), BOSTON, MA, USA, 8-11 SEPT. 1998, vol. 1, pages 335-339, XP002160825 * page 335, left-hand column, paragraph 2 - page 335, right-hand column, paragraph 2 *	1-18	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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